AN EXPLORATION OF HUMAN-CENTERED DESIGN AS A MEANS TO IMPROVE RADIOLOGY ENVIRONMENTS IN PUBLIC HOSPITALS IN SOUTH AFRICA

by

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ACKNOWLEDGEMENTS

I dedicate my thesis to my parents, who have always been my biggest supporters, and who have never considered my field or my career to be 'just design'. It turns out I *do* have an interest in the medical field. Just not as a medical doctor.

To my brother, Ben: thank you for always looking for ways to improve and streamline things. If it weren't for you brainstorming how you could improve the software system integration at Universitas, I doubt I would have found this topic and field that I have become so passionate about.

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I can't wait to answer the question "Is there a doctor in the house?!" with "Yes! Which design framework would you like to discuss?!"

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ETHICS STATEMENT

The author, whose name appears on the title page of this dissertation, has obtained, for the research described in this work, the applicable research ethics approval.

The author declares that she has observed the ethical standards required in terms of the University of Pretoria's Code of Ethics for researchers and the Policy Guidelines for responsible research.

Lizette Spangenberg
August 2022

ABSTRACT

This thesis explores the landscape of human-centered design as found in South African healthcare. It then applies this framework in the context of radiology departments and environments in public hospitals in South Africa. Various design approaches as well as design processes are investigated, critiqued, and compared. By doing so a design framework purpose-built for use in a South African healthcare environment is created, and a case study is conducted. The end result being recommendations for improvements in radiology environments to address the specific themes that emerged from research.

Key words
Human-centered design, design approach, design thinking, design process, health humanities, reframing, radiology, work experience, public hospitals

CHAPTER ONE
INTRODUCTION

1.1 Background and aims of study

1.1.1 *Background*

This thesis explores and proposes a human-centered[1] design approach in a South African context, and then applies this framework in the context of radiology departments and environments in public hospitals in South Africa. This is a means of exploring and addressing issues that are prevalent in these spaces. Human-centred design has a long history, with roots that can be found in practice-based applications in the 1970s (Steen 2011:49; Greenbaum & Kyng 1991; Törpel 2005), to theory-based design in the 1990s (Norman 2013:xiv; Grudin 1990; 1993; Blomberg *et al* 2009:72), and again back to a practice-based methodology with various approaches in the 21st century (Clancey 2016:24; Dam & Siang 2020; Stanford d.school 2011).[2] The essence of a human-centered design philosophy is to place people at the heart of creating solutions, and to design systems that enhance human knowledge instead of undermining it with technology (Cooley 2008).

Radiology is a specialised field within medical science that aims to diagnose diseases by obtaining and interpreting medical images of patients. There are various ways that these images can be obtained, ranging from using X-rays, to radioactive substances, to sound waves, to the body's natural magnetism (Radiological Society of South Africa [sa]). To appreciate the complex nature of a radiology workspace under discussion in this study, it is necessary to first explain the 'actors' in this space, as well as the workflows that they engage in. This is done below:

- *Radiologists* are physicians that, after obtaining their medical degrees, have gone on to specialise in the field of radiology for another five years to interpret X-rays and scans (Radiological Society of South Africa [sa]). Radiologists can choose to work in public or private hospitals, and very rarely interact with patients. Their focus is on interpreting the diagnostic imagery that has been generated.

- *Radiology registrars* are physicians enrolled in a four-year programme at a university to become consultants in radiology: also known as radiologists. Registrars work under the

[1] While this thesis follows British English spelling standards, the discourse around human-centered design has been driven by American scholars and the term has become technical. Therefore American spelling is used for the term "centered" throughout this thesis, instead of the British "centred".
[2] This background is discussed in detail in Chapter 3, starting on page 15.

supervision of already-qualified radiologists and professors, and are required to work at academic hospitals – public hospitals affiliated with a university – where medical students and registrars receive their practical training. This forms part of their community service which is a part of the degree. They are not allowed to work unsupervised or in private hospitals (Radiologist 1 2019b).

- *Consultants* are physicians that have already completed their specialisation degree and continue to work at academic institutions in their speciality. They form part of the academic department and help to train registrars in their field, such as emergency medicine, vascular surgery, orthopaedics, or diagnostic radiology. Consultants are only allowed to oversee 4 registrars, to ensure they are able to give enough guidance and oversight to each registrar.

- *Radiographers* form part of the diagnostic team by interacting with patients and explaining procedures to them, operating the machinery and positioning patients on it, as well as producing the X-rays and scans that radiologists use to make diagnoses. They do not hold medical degrees, but do require formal training of up to four years before working in this field (Radiological Society of South Africa, sa). Radiographers also tend to specialise in specific modalities. For instance a CT radiographer would have undertaken an additional course to specialise in CT scans. The same with MRI radiographers and mammogram radiographers. Radiographers can work in either private or public hospitals.

- *Physicians* or *clinicians,* in this context, refers to doctors working outside of the radiology department. They may be associated with any of the other departments in a hospital such as emergency medicine, surgery, or orthopaedics.

- *Patients*, in this context, refers to the persons that have been referred by other physicians to undergo X-rays or scans. There may be various reasons why a patient may need an X-ray or a scan. This is generally because the referring physician requires more information in order to diagnose or treat the patient. In the case of a broken arm, a doctor may need to see an X-ray of where the fracture is and whether the patient needs surgery. Whereas in the case of a suspected brain-tumour, an MRI scan – which is a lot more time-consuming and expensive than an X-ray – may be able to confirm its existence, as well as indicate the size and location.

When it comes to the technology used to perform various scans and internal imagery reconstructions, research into this field tends to be quickly incorporated into very hi-tech software programs, systems and machines used to perform various scans that radiologists use daily. This new research may allow for anything from more advanced diagnostic features, to higher-resolution images to view, or even be

a new type of examination that is available to perform. However, as noted through preliminary research for this study, in most of this research the "human" element is often forgotten and the focus is mostly on clinical data or advances in techniques. This does not refer to the patient who is being examined, although this is also a very important field of research that is often overlooked. In this case, the radiologist, registrar or radiographer involved in the radiology workflow is the "human" element to be considered. There is no scholarly discourse currently on the people involved in conducting this process. Furthermore, the consideration that a person may be using this technology in a developing country that has unique limitations is also generally overlooked and not catered for by the companies creating the hard-and-software used in radiology workflows, nor is it discussed in scholarship. This is a gap that this research aims to address.

In South Africa there are two types of hospitals: private hospitals that are privately owned and run by companies – Netcare and MediClinic are two of the well-known hospital networks in this sector – and public hospitals that are owned and operated by the government. Public hospitals have various limitations and unique requirements, generally owing to budgetary constraints. Therefore cutting-edge software designed and built in developed countries to be run on the latest computer hardware, connected to the latest radiology machines, may simply not be feasible in a South African public hospital. This is often because the budget and systems to implement it are not available.

An overly simplistic solution might be to suggest allocating more money to all public hospitals to ensure that the latest technology is available, but this is simply not realistic. Government budgets in South Africa (and indeed any country) are a "wicked problem" [3] and are not easily changed or solved. The term "wicked problems" was coined in the 1960s by Horst Rittel, a mathematician, designer and teacher (Buchanan 1992:15). He describes them as "a class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications of the whole system are thoroughly confusing." There are no clear solutions to these kinds of problems, and Rittel argues that most of the problems that designers face are wicked problems. This gets to the very heart of problem-solving through human-centred design, which is that something as abstract and difficult to solve as government budgets is not the problem in this case. Or at least it cannot be the best way to interpret the problem space,[4] since it is something that cannot be changed on a meaningful level by this research study or any design intervention. This becomes one of the parameters of this problem space that will need to be considered when searching for solutions.

[3] Wicked problems are discussed in detail in Chapter Three, starting on page 74.
[4] The term "problem space" is coined by Simon (1973) and discussed in more detail starting on page 69.

Radiology environments are indeed a "problem space" and not merely a "design problem". Kees Dorst (2006:10), one of the seminal design researchers referenced in this thesis, maintains that one cannot presuppose that there is such a thing as a set "design problem" at any one point in the design process. It is also difficult to identify a specific "design problem" because it evolves during the design process, and the very considerations that make up the idea of a "design problem" change owing to the design effort (Dorst 2006:16). It is, instead, a combination of different problems centred around the general challenge. Buchanan (1992) reiterates that design thinking and decision making do not adhere to a strictly linear process, and also do not fit into the traditional thought pattern of the design process being divided into two phases, namely, problem definition, and problem solution. It is this "combination of problems" that creates a problem space, which Dorst (2015:2) identifies as "open, complex, dynamic and networked". Design includes problem solving, but cannot be reduced to it (Hatchuel 2001). Beckett (2017:7) echoes these ideas and suggests that a design problem cannot be truly formed until its solution has been determined. This paradox again infers that design problems and solutions influence one another. This ties into the work of Nigel Cross (2006:57), who identifies that a "creative leap" is required to close the chasm between problem and solution.

Another parameter in the problem space under discussion here is the age of equipment, which is often between 5 and 10 years old (Radiologist 1 2019a). Private hospitals and private radiology practices are often able to acquire newer and more advanced technology because they have more funds available to them; their budgets are not reliant on government funding. Therefore, while private radiology practises in South Africa do still use (and need) different workflows from developed countries, the limitations are not quite as many as for public hospitals, and are not the focus of this study. Radiologists in private practice will still be consulted, however, as they can still provide valuable insights about working in a South African context. All radiologists who have studied and graduated in South Africa have had to work in public hospitals during the course of their specialisation, and are therefore familiar with their workings. Instead of focussing on issues that cannot be easily addressed like the aforementioned budgets and funding, this study proposes to first investigate and identify issues that *can* be addressed in radiology departments and environments in South African public hospitals, and then explore how human-centered design can be used to address or mitigate these issues.

A case study on using human-centered design to improve an experience in the medical field – specifically radiology – can be found in the "Adventure Series" that was developed for use in children's hospitals' radiology departments in America in 2010 (Dietz 2012). Doug Dietz, an industrial designer for General Electric Healthcare, a large developer and supplier of radiology equipment, designs Magnetic Resonance Imaging (MRI) scanners. Dietz explains in a 2012 TED talk that during a site visit to inspect the installation of a new machine in a children's hospital, he found a little girl crying about

having to undergo the scan. He suddenly looked at the machine he was proud of designing through a child's eyes: it is beige, huge, clinical, and intimidating (Figure 1).

Figure 1: An MRI scanner *in situ*, Stanford Health website, 2022.

A scan typically takes about 45 minutes and involves a patient lying perfectly still on a table that slowly moves in and out of a large metallic tube while the machine clicks very loudly (Radiologist 1 2019a). Dietz learnt that around 80% of children had to be sedated for the procedure, which requires an anaesthetist. The whole process was usually distressing for patients, parents, doctors and radiographers. It also reduced the number of patients that could be scanned in a day. This increased costs associated with the procedure, and also increased the risk and complexity of the scan. Dietz and his team set about exploring solutions, focussing first on creating better experiences for paediatric patients. As part of their design process they went to a day care centre for a brainstorming session. Dietz states that while the children were drawing, one child kept pushing his crayon into the cracks on the table instead of drawing on the paper. This made him realise that he had to learn more about the developmental stages of children in order to understand what was causing them anxiety (Dietz 2012).

By engaging children's imaginations, Dietz and his team at GE created the "Adventure Series". They designed various rooms with different themes that engage the senses in different ways, including visual imagery, lighting, aromatherapy and storylines that integrate with the different rooms (Figure 2). A special type of virtual reality goggles that do not contain any metal[5] were also developed for use by patients during scans. This allowed them to watch a story related to the theme of the room. Some of the radiographers that perform the scans even wear themed clothes (Dietz 2012).

[5] An active Magnetic Resonance Imaging (MRI) scanner is an incredibly powerful magnet. Therefore no metal objects are allowed in the room as it could potentially hurt the patient or damage the machine.

Figure 2: An 'Adventure Series' MRI scanner installed at the Children's National hospital radiology department, Rockville (Ford 2014).

Dietz (2012) states that he knew their design was a success when he overheard a young patient who had just undergone an MRI scan in one of the newly redesigned rooms asking her parents if they could come again the next day and do it again. While tears welled up in his eyes, he noticed that the radiographer was also crying. She thanked him for reminding her why she had gone into paediatric radiology in the first place. It had become painful to her to see patients suffer while she was trying to help them, and seeing the patients enjoy themselves had made her job more enjoyable as well. In the two years since the Adventure Series' implementation, only two children had needed to be sedated, and 27 hospitals across America had implemented the Adventure Series in their radiology suites. By using a human-centered approach and placing the paediatric patients and their comfort first, Dietz and his team managed to make the experience of getting an MRI scan more enjoyable, while simultaneously saving the hospital money in terms of needing sedation, increasing patient turnover, and making radiographers and doctors' jobs more enjoyable again: a positive outcome for everyone.

This solution of creating colourful, engaging designs that incorporate children's imaginations may seem obvious. However, the reality is that the solution was never previously considered, because it was never realised that there was a problem that could be solved in the first place. It was simply accepted that these procedures were unpleasant and sedating patients was the norm. By looking at the *people* involved in the overall process, Dietz and his team created a solution that has positively affected many patients and healthcare providers.

While colourful, playfully-themed rooms may not be the appropriate solution to improving environments and workflows for radiologists in South African public hospitals (although it could – one cannot be absolutely certain before one has begun to properly research the problem space), it does show that by first designing for the person who would be experiencing or using the system, one can create unique solutions that could have substantial benefits for the person, practitioners, as well as the overall institution.

Through a brief initial feasibility study and contextual inquiry at Universitas Academic Hospital in Bloemfontein – a public hospital associated with the University of the Free State – guided by a qualified radiologist who worked there for 5 years (Radiologist 1 2019a), various frustrations and pain points in the current radiology environment immediately became apparent. Examples include outdated technology, cumbersome work-arounds involving multiple systems, inconsistent design of software interfaces, as well as physical spaces that do not always yield the best working environments. In Chapter Four an in-depth case study has been conducted by consulting with registrars at Universitas Academic Hospital. This has allowed common frustrations and pain points[6] to be identified, and overarching themes to emerge. By applying a human-centered philosophy, solutions have been proposed to improve these experiences.

This thesis is situated in the research space of health humanities; an interdisciplinary field that sits at the intersection of humanities and healthcare, health and well-being (Crawford, Brown, Baker, Tischler and Abrams 2015)[7]. The field has several tasks, specifically looking at (1) new pedagogical approaches informed by utilising arts and humanities in the education of professional personnel involved in healthcare, (2) promoting the health benefits of being involved in arts and humanities, (3) exploring the existing therapeutic applications of the arts and humanities in healthcare, (4) democratising therapeutic interventions to not be limited to specialist professionals, and lastly (5) advocating for sharing arts and humanities resources and the capacities of healthcare workers and patients in order to improve healthcare environments (Crawford *et al* 2015:1-2). This last point, which in our case is formulated as using design to improve healthcare environments, is what concerns this thesis in particular.

1.1.2 *Aims and objectives of the study*

This study has three aims, each of which has a number of objectives. These support one another in order to reach the overarching goal of this thesis, which is to contribute novel design research.

[6] Pain-points are keys and not doors; they are ways into design problem spaces but seeing them as the defining aspect of any problem space would be to fall into the dialectic of problem-solution that this thesis is trying to avoid.
[7] Professor Paul Crawford is the world's first Professor of Health Humanities, based at the University of Nottingham (Crawford *et al* 2015).

The first aim of this thesis is to establish how human-centered design can be utilised in a South African context. Chapter Two is dedicated to this aim. To this end, there are three objectives to be met. The first is to understand the broader philosophy of human-centered design especially with regard to how it developed. This is done by means of a literature review in Chapter Two. The second objective is to compare different kinds of design approaches that can be utilised, along with advantages and limitations of each. This is again done by means of a literature review, as well as an analysis of each approach. The third objective is to understand how human-centered design has been applied to healthcare in general, as well as in a South African context before and to what types of problems.

Chapter Three explores the second aim of this thesis, which is to develop a design framework underpinned by human-centered design that can be used in a South African radiology context. To this end the fourth objective of this thesis is to explore and compare existing design processes through a literature review, along with analysing each. After this, a framework to suit this particular problem space is crafted, which is the fifth objective.

In order to put the theory discussed in chapters Two and Three into a practical context, a case study is conducted in Chapter Four. This speaks to the third and final aim of this thesis, namely, investigating how human-centered design can be used to improve radiology environments in public hospitals in South Africa. The sixth objective is to apply the design framework that has been developed and follow the process by means of a case study. As part of this process, interviews are conducted with radiology registrars in a public hospital, as well as qualified radiologists in private practice. This achieves objective seven, which is to develop a thorough understanding of existing radiology workspaces and environments in public and private hospitals in South Africa. Lastly, hypotheses of possible solutions to the problems are created, which are objective eight. The purpose of this research is to show how human-centered design can be utilised to reframe and innovate spaces and problems in healthcare environments that have simply been accepted as the norm.

1.2 Literature review

As noted above, although much research has been done on human-centered design, very little of it has been done in the context of South Africa. The research that *has* been conducted is discussed in this section. No research has been done on using a human-centered design approach to investigate radiology workspaces and environments – in South Africa or internationally. This is a gap that this thesis aims to fill.

The International Organisation for Standardisation (ISO 1999) defines five essential processes that need to be undertaken in order to incorporate human-centered design into the software development process:

1. Plan the human-centred design process.
2. Understand and specify the context of use.
3. Specify the user and organisational requirements.
4. Produce designs and prototypes.
5. Carry out user-based assessment.

Maguire (2001), in his article, "Methods to support human-centered design", makes reference the aforementioned ISO approach, and compiles lists and tables of various methods that can be used in each of the four steps. It provides practical guidance on what methodologies to be used when, and has been referenced in formulating the methodology for this study.

Buchanan (1992) discusses wicked problems and names ten properties that make them difficult to solve, such as the fact that they have no definitive formulation and no stopping rules. He maintains that design problems are "indeterminate" and "wicked" because design does not have special subject matter of its own beyond what a designer considers it to be. This ties directly into Dorst's (2006) idea that *how* the problem space is defined in the first place is subject to the problem solver, therefore that person – the researcher, in this case – influences the very nature of the problems that are being solved. This research project will therefore attempt to define the researcher's capabilities and how it may influence the problem space analysis.

Dorst (2006, 2015) writes extensively on "design problems" and how these are almost never straightforward or easy to solve. Dorst (2006) maintains that there are two types of problems: well-structured and ill-structured: a distinction which was first stressed by Herbert Simon. Ill-structured problems cannot be clearly defined at the outset and evolve as one gains more context. Dorst (2015:2), in his book *Frame Innovation,* describes these problems as "open, complex, dynamic and networked", as mentioned earlier. To approach these kinds of problems, – which this study proposes radiology environments represent, Dorst introduces the concept of "reframing": the idea of framing complex problems in new ways in order to find new solutions. The steps inherent in this reframing paradigm will be used for this study as a way to find novel solutions to problems.

Beckett (2017) echoes Dorst's research on design problem states, and proposes that design problems be explored dialectically: "by viewing the design problem and its solution as moments of a concept undergoing a dialectical process". In other words, because design problems can rarely be clearly defined at the outset, only when a solution is determined can the design problem itself be truly defined.

Therefore while the ISO's processes would be well-suited to Dorst's idea of a well-structured problem that can be solved in a linear fashion, since the problem space at hand is ill-structured, it would be more prudent to rely on Dorst's reframing structure as a primary framework. The steps from the ISO processes are incorporated into this framework. This is discussed in more detail in the methodology section below.

IDEO.org (2015) is the non-profit branch of an internationally renowned design agency that aims to inspire change, and has created a "Field Guide to Human-Centered Design" to enable anyone to apply this approach to the problems they are seeking to solve. It provides various practical methods and ideas, and provides some practical ideas for methodologies that can be incorporated. IDEO.org has more recently partnered with the Ellen MacArthur Foundation[8] (The Circular Design Guide 2018) to work on a paradigm they're coining as "circular design": the idea that design should not just focus on a solution, but should be a cyclical process that constantly reevaluates the changing landscape it finds itself in. Constant reflection is important in any process, and has been considered in this thesis.

Kaiser Permante is an American integrated managed care consortium that places a lot of focus on human-centered design when creating solutions and processes for its members. Their practises are discussed by various researchers – Carlgren (2016), Bazzano and Martin (2017), Bazzano *et al* (2017) and provide a valuable starting point for considering human-centered design in healthcare.

Vagal, Wahab, Butcher, Zettel, Kemper, Vogel and Mahoney (2020) write on *Human-Centered Design Thinking in Radiology.* They discuss the Live Well Collaboration design thinking process model in context of radiology, and discuss the benefits of human-centered design.

Looking at human-centered design in a South African context, little has been researched or published in this regard, possibly because there are few designers that work in academia with a focus on human centered design. Bowie and Cassim (2016), Chmela-Jones (2013, 2015), Harvey (2013), Hobbs and Fenn (2015), and Schaefer (2015) all consider human-centered design in the context of design pedagogy. Barnes and du Preez (2015), Carstens (2015) and Fenn (2015) write on the value of incorporating human-centered design into the design process. Arguably, some of these developments are a delayed response to Buchanan's (2001) reflection on how human-centered design can be utilised as a means for bringing about social change in South Africa. Ria Van Zyl (2006) utilises a human-centered design approach in a multi-disciplinary team to design a new type of donkey cart for rural areas in South Africa. Sauthoff (2004:24) encourages the use of design thinktanks and cross-

[8] The Ellen MacArthur Foundation ([sa]), a charity founded in 2009, aims to accelerate the transition towards a 'circular economy'. This is designed to eliminate pollution and waste, regenerate nature, and circulate products and materials. Their vision is an economic system that is better for the environment and people, and they work with business, academia, institutions and policy makers to accomplish this.

disciplinary participation to find solutions to specified problems as South Africa presents a complex environment.

The South African National Health Research Database (NHRD 2022), a repository for all health-related research that has been or is currently being conducted in South Africa, lists no published studies on human-centered design in healthcare in South Africa. The research that has been done on combining human-centered design and the field of radiology internationally has been focussed either on patient care, or on including human-centered design approaches into applications or interfaces for computer systems. Again, none of this research has been done in a South African context, and thus does not take into full account many of the problems that are unique to this context. This therefore points to a gap in the research which this study aims to fill.

Samaras and Horst (2005) advocate for incorporating human-centered design into the design and development of health information systems. Zhang *et al* (2002) and Markonis *et al* (2015) look at how human-centered design can be used in displaying complex information, as in radiology reports and on medical image retrieval systems. Lathan *et al* (2000), Rawson and Moretz (2016), as well as Salmon *et al* (2015) use human-centered design as a means to look at and improve patient care and radiology procedures.

1.3 Theoretical framework and research Methodology

This study is conducted under a qualitative paradigm[9] as it concentrates on interaction, environmental experiences, and other intangible aspects, as opposed to measurable data. It is situated within the interdisciplinary field of Health Humanities which, amongst other aims, is marked by a desire to enhance healthcare environments (Crawford *et al* 2015).

One of the novel contributions of this thesis is the creation of a new design framework, according to which the case study in Chapter Four has been conducted. It is a combination of other processes, and its genesis and structure are discussed in detail in chapters Three and Four. Because of this, only a brief overview of the steps is given below. Figure 3 shows the visual representation of the steps.

[9] While 'checks and balances' are often included as means to validate a qualitative research design, this has not been deemed possible for this type of study, considering the constraints that were faced. These include physical constraints in the face of the Covid-19 pandemic, as well as time and availability constraints from research participants. More can be read about constraints on pages 35 and 40. A 'check' that can be considered is studies that are referenced where similar interventions have been attempted and have either succeeded, or are likely to succeed. These have been included in the formulation of potential solutions.

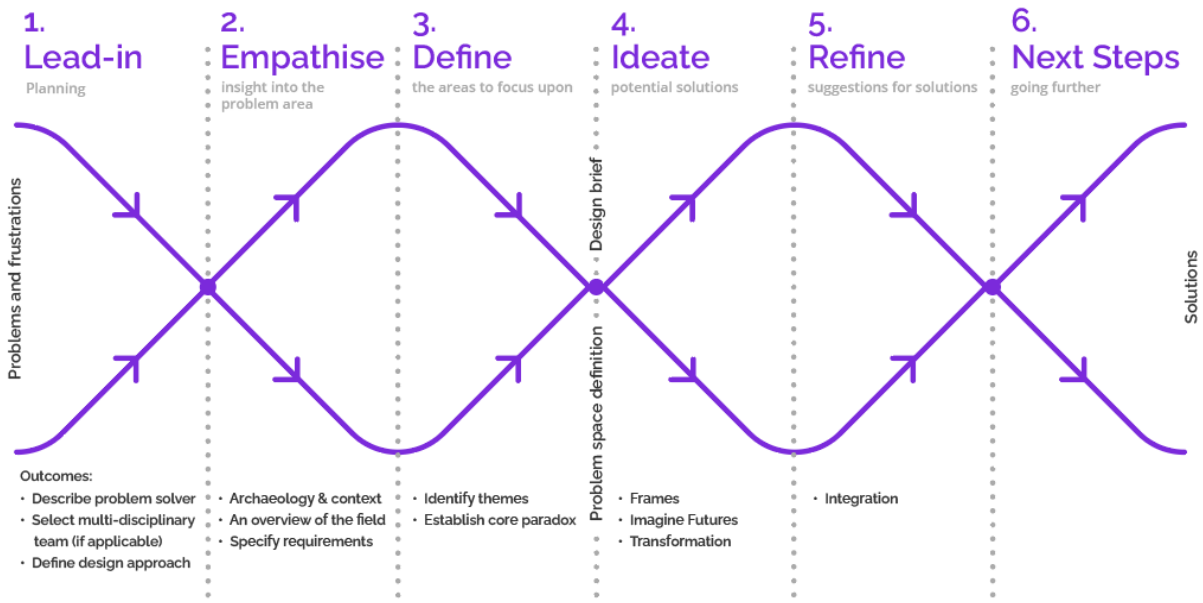

Figure 3: Design thinking reframing process. Diagram by the author 2022.

As mentioned previously, design problem spaces do not present clear 'design problems' to solve. Therefore, although initial problems may be identified, these will in all likelihood evolve with the development of solutions, with true design problems only being defined alongside their proposed solutions.

1. Lead-in phase

Methods to be used

- Brainstorming / ideation

Outcomes

- Description of the problem solver
- Selection of multi-disciplinary team (if applicable)
- Design approach defined

2. Empathic discovery phase

Methods to be used

- Qualitative data collection
- Literature review

Outcomes

- Archaeology of the problem situation and context
- An overview of the field
- Requirements specified

3. Definition phase

Methods to be used

- Affinity mapping

Outcomes

- Themes identified
- Core paradox established

4. Ideation phase

Methods to be used

- Brainstorm / ideation

Outcomes

- Frames
- Imagining Futures
- Transformation

5. Refine phase

Methods to be used

- Critical analysis

Outcomes

- Integration

6. Next steps

While this may seem like a linear process, if deemed necessary, a phase or previous phase may be repeated. This may also occur if the understanding gained through the process of the phase changes the understanding of requirements. This is discussed in detail in Chapter Four. Numerous steps were repeated during the process, and not all steps occurred in the order initially proposed. This process mirrors a dialectical process: as solutions are created, problems may be redefined, and vice versa.

1.4 Overview of chapters

This study commences in Chapter Two with a focus on human-centered design. This allows for a better understanding of how the philosophy developed, and where its principles stem from. This discussion aims to give a holistic overview of the benefits and criticisms of human-centered design. Other considerations, such as community interventions, design for business, and design as anthropocentric, are also discussed. After this, the rest of the chapter is dedicated to discussing different design approaches with an overview of each, their advantages and limitations, as well as examples of where

they have been implemented in South Africa, as well as in healthcare design. An analysis of how each approach relates to this project and its feasibility follows. Chapter Two concludes with an overview of human-centered design approaches – the first novel contribution that this thesis offers.

Chapter Three investigates design problems, design thinking and design processes. Design problems are discussed, formulated and defined, as well as the enigma of how problem *spaces* tend to be much more prevalent than design *problems*. The problem solver is also investigated. A history of design thinking as well as different practical processes used to find solutions are dealt with. An overview of each process is given, critiqued in terms of how well the process fits into the requirements of this thesis. The steps of the different processes are compared in table form, and the democratisation of design – making design accessible to non-designers – is contemplated. Finally, the design framework for this study is constructed by combining the relevant parts of previous processes discussed, and the methodology is discussed in detail. In this way a unique framework is created for a South African context.

Chapter Four utilises the newly-created design framework to conduct a case study designed to improve a radiology environment in a public hospital in Bloemfontein, South Africa. Each step of the framework is followed, starting with a description of the problem solver, namely this author. Themes from interviews conducted with seven registrars are extracted and used to generate hypothetical solutions, which are discussed regarding feasibility and their problem solving value.

Chapter Five concludes with a summary of the chapters, listing the contributions and limitations of the study, and suggestions for areas of further research.

PART ONE

THEORETICAL CONTEXT

CHAPTER TWO

HUMAN-CENTERED DESIGN

The first chapter looked at the background to this study, outlined the methodology and presented a literature review. This chapter turns to human-centered design, its development, benefits and critiques, and ends with a discussion on the different approaches that can be undertaken as part of the human-centered design approach. Each of the approaches is investigated and critiqued in depth. Their advantages and limitations are discussed, as well as their applications to the South African healthcare environment. I consider design examples needed to elucidate certain theoretical concepts. These concrete examples function as analogies for some of the concerns being explored. Each approach is also discussed and critiqued in the context of this thesis.

Design is by and large created for and by people, in fact, anything outside of nature is to some extent designed.[10] Design can take many forms. Some of these concentrate on process and optimisation (like mechanical engineering), others on visual communication (illustration, graphic design, typographic design), and others on practical application (product design, furniture design, textile design). In a field like healthcare, the protocols and instruments used, clothing and even the chemical composition of medications are designed. For the purposes of this research, "design" is used both as a noun and a verb, depending on the context. In this chapter, it is primarily defined as the "purpose or planning that exists behind an action, fact, or object" (Lexico 2022). This is because human-centered design is not an object or even a process, it is an abstract *philosophy.*[11]

The Oxford English Dictionary[12] (2021) and Merriam Webster Dictionary[13] (2021) definitions of "design" do not overtly mention or discuss the *people* designs are created *by* or *for*. The definitions are focussed on the processes, the end-products or the concepts, not the people involved in the processes.

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[10] Even nature can be designed to some degree, as in the case of gardening, landscape architecture, and bonsai trees that are strictly pruned to grow in certain shapes, for instance.

[11] This raises the question of what the axiological and philosophical position of human-centered design is. Human-centered design assumes human rights, but what does this really mean? This is a question referred to future research, as it is a meta question and outside of the scope of this thesis to address.

[12] The Oxford English Dictionary (2021a) defines design firstly as a *noun*:

1. a plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is made.
    - the art or action of conceiving of and producing a plan or drawing of something before it is made.
    - the arrangement of the features of an artefact, as produced from following a plan or drawing.
2. a decorative pattern.
3. purpose or planning that exists behind an action, fact, or object.

And secondly as a v*erb*:

decide upon the look and functioning of (a building, garment, or other object), by making a detailed drawing of it.

- do or plan (something) with a specific purpose in mind.

[13] According to the Merriam Webster Dictionary (2021), design can be defined as "to create, fashion, execute, or construct according to plan", or "to have as a purpose".

It can be argued that this is implicit – most objects are created for human use or consumption – but by downplaying the presence of the person performing the act as opposed to the action itself, it leaves design open to being done "for its own sake" as opposed to being created for *people* who will benefit from it or find value in it.

To an extent the same critique can be applied to the philosophy of human-centered design itself. As discussed in this chapter as well as Chapter Three, the focus does often drift towards the process or act of *designing* itself, and become less on the *human-centered* aspect. The emphasis tends to be greater on methodology or process than on the *people* being designed for.

By considering and comparing various human-centered design principles, I have compiled the following list of five central guiding principles for human-centered design:

1. *Gain a thorough understanding.* (Norman 2019; ISO 2019)
   Understand users, tasks environments explicitly, so that the right problems, the core problem and not just the symptoms thereof, are addressed. It is vital to ask 'why' at every step of the process. If the answer is human error, then it needs to be understood why it occurred and what could have prevented it. This step demands thorough research.
2. *Follow a people-centered approach – put people first.* (Norman 2019; ISO 2019; Maguire 2001:588)
   Consider all parties involved in any given system and actively involve them. In the case of healthcare, this means considering patients, doctors, nurses, porters, cleaners, pharmacists, as well as any other support staff. As far as possible, sociological factors should be included as well.
3. *Incorporate multidisciplinary design teams.* (Maguire 2001:588; ISO 2019)
   Human-centered design involves a collaborative process that benefits from the insights, perspectives and skills that people with varying abilities can provide. Thus, the design team may include designers, managers, usability specialists, stakeholders, as well as support staff and end-users.
4. *Consider the system and experience as a whole, not just isolated components.* (Norman 2019; ISO 2019)
   Everything in a system is interconnected, and optimising parts of a process may not necessarily result in optimisation of the whole.
5. *Follow an iterative process.* (Norman 2019; ISO 2019; Maguire 2001:588)
   Design solutions should be performed repeatedly upon receiving feedback from those using the systems, as well as stake-holders, and then tested. This ensures that the design is developed further and different perspectives are catered for.

It is important to investigate how and why human-centered design became a prominent design movement.[14] It has been described as a philosophy, a process, a framework, a field, and a movement, to mention a few, but, for the sake of this thesis, it is considered an *intention*. Regardless of the methods or approaches used, human-centered design is meant to be at the heart of the entirety of the design process, whether it be research or crafting solutions.

Human-centered design has evolved from being practice-based in the 1970s (Steen 2011:49; Greenbaum & Kyng 1991; Törpel 2005), to theory-based in the 1990s (Norman 2013:xiv; Grudin 1990; 1993; Blomberg *et al* 2009:72), and back to a practice-based methodology with various approaches in the 21st century(Clancey 2016:24; Dam & Siang 2020; Stanford d.school 2011). These different ideas of what human-centered design is are discussed in this chapter, along with their origins, and modern applications. Practical frameworks for applying human-centered design in practice are discussed in the next chapter, together with design thinking and methodologies for applying these. These are discussed with regard to their application and feasibility in a South African context, with particular emphasis on healthcare design. This thesis focusses on human-centered design which is an area of research that traces its origins back to technological applications, but has also been successfully applied in real-world situations.

2.1 The development of human-centered design as general philosophy

Philosophically speaking, the principle of including people in the solutions you are creating can be traced back to ancient Greece and Plato's *Republic*, where the philosopher was known to invite citizens to participate as a community making decisions in matters of designing the city-state (Sanoff 2006). Many scholars have developed approaches that stress human values in their design, long before the notion of "human-centered design" became commonly accepted. Some have become more defined as time has passed, while others frame the general philosophy.

Arnold (1959) defines his term "creative engineering" as referring to the idea that engineers (such as his protégé McKim[15] (2016), an industrial designer and engineer), straddle the worlds that form the "creative engineer" Arnold describes. He expressed the core values of human-centered design long before the term was coined, stating that his engineering firm's consideration of "human factors" contributed well in terms of public relations. However, frequently designs suitable from a human

[14] This speaks to the first objective of this chapter, namely understanding the broader philosophy of human-centered design especially with regard to how it developed. This ties into the bigger aim of this chapter, which is formulating how human-centered design can be utilised in a South African context.
[15] McKim and Arnold originally gave these seminars in 1959, but they were only published by Clancey (as editor) in 2016. Clancey also wrote an introductory bibliographic essay on Arnold, included before the seminars.

perspective, were interpreted superficially. He believed that engineers who claimed they were "designing for people" were rationalising their choices instead of starting with a holistic understanding of human needs (McKim in Clancey 2016).

McKim (2016:204) describes a method now termed "human-centered design" as the notion that people should not only be considered after a functional design has been completed, but should be consulted from the start:

> If our human values are such that we consider the machine to be an extension of man, with man the boss and the machine the servant, then early consideration of man's physical relationship to the machine becomes of obvious importance. By early inclusion of man into the design hypothesis as a non-variable, it is usually possible to accommodate the other design variables to man's physical nature. Once the design is partially "set," however, the designer will often begin to consider man the variable. Man, unfortunately, is not a variable—he has *already been designed*. Only early inclusion of man into the design process can bring man into his proper relationship with the machine. [Emphasis added by the author]

Mike Cooley coined the term "human-centered systems" in his 1982 book *Architect or bee?: The human/technology relationship.* This term later evolved into what we now know as "human-centered design". He asserts a seemingly obvious, but neglected idea, that people should take precedence over machines, no matter how elegant or complex the machine may be. This is the essence of human-centered design: placing people at the heart of creating solutions, and designing systems that enhance human knowledge instead of undermining it with technology (Cooley 1999).

What does human-centered design then actually involve? The International Organisation for Standardisation defines human-centered design (ISO 2019) as follows:

> Human-centred design is an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, usability knowledge, and techniques. This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance.

As evidenced by this definition, human-centered design is not a prescriptive paradigm as it leaves considerable room for interpretation regarding its application. Little research has been done on human-centered design in a South African context, and no research has been done on how it can be applied to the context of radiology – internationally or in South Africa.

Giacomin (2014:612-613) proposes that the most successful examples of human-centered design in the 21st century all answer an incremental set of questions, as seen in Figure 4. Each level grows in complexity, and culminates in "Meaning (Why)." Meaning is created either through contact or pre-existing, and is considered the key to the solution's success. As with Maslow's hierarchy of needs, this presents a tenuous metaphor, as it implies scaffolding that may not exist in reality. This theme of "simplifying" design and its processes is discussed later in this chapter as well as in the next. The

question is at what point does the focus shift from "finding human-centered design solutions", to merely "defining processes to be followed in order to find solutions"?

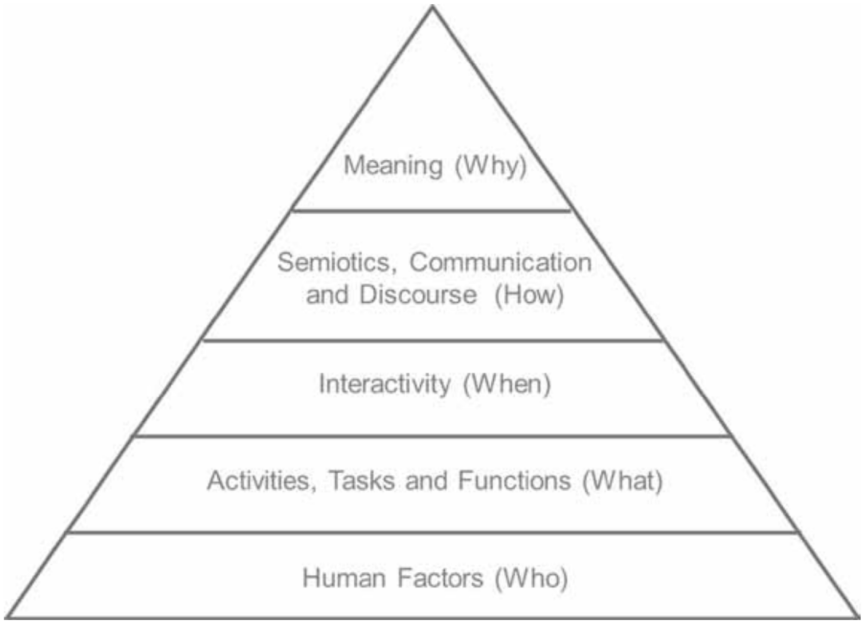

Figure 4: The human centred design pyramid. (Giacomin, 2011).

Giacomin (2014:612-613) maintains that the modern designer is relatively transparent and does not impose their own opinions, values and preferences on a project, but instead, allows themselves to be led by the conversations and the will of those involved. In theory this is a good principle, but the idea can only remain theoretical. In fact, as is expanded on in Chapter Three with reference to Dorst (2006), the person involved in problem-solving directly influences the nature of the problem through their involvement. The problem-solver inherently becomes an *agent of change.* Their skills as a problem-solver, their knowledge about the subject matter as well as their frame of context, all play into unintended biases. By claiming to remove all bias, bias may simply be made unconscious but will still influence the outcome.

2.2 Benefits of using human-centered design

Having briefly investigated some key aspects of the evolution of human-centered design, and the principles that guide it, a question needs to be answered in this regard: why adopt human-centered design? Why should this approach be used above others? First and foremost, it bridges the gap between researchers and those using the systems they design for (Steen 2008:25). It also allows for constructive cooperation between multi-disciplinary teams. As the name suggests, it also focusses holistically on *people,* thus seeking a much more empathetic and embodied approach than merely designing abstract systems.

According to the International Organisation for Standardisation (ISO 9241-210:2010) human-centered design has substantial economic and social benefits:

a) Increased productivity and operational efficiency
b) Reduced training costs by being easier to understand and use
c) Increased accessibility for people with disabilities or that are differently abled
d) Improved user experience (in the case of digital interfaces)
e) Reduced stress and discomfort
f) Competitive advantage
g) Contributes towards sustainability objectives

Many of these benefits are problematic. The first one, "increased productivity and operational efficiency" indicates how design (and the people creating it) may be used as a tool for a process or for the sake of an impersonal system. Points (f) and (g) point toward business benefits for the company – again using human-centered design as a means to an end, not as something valuable in itself. In order to remain ethical, human-centered design should always treat people as a priority and not as a means to achieve another aim. It is easy (and tempting) to allow other agendas to take over.

2.3 Limitations of human-centered design

While many valuable insights can be gleaned from employing human-centered design, it is not considered a tool for understanding and studying people's needs, neither as a tool for controlling product development (Steen 2008:26). It is intended to spark new ideas, and let subjects influence the research process.

While human-centered design demonstrates clear benefits such as faster learning times, improved usability and fewer errors during usage, Norman (2005:16) highlights the risks of blindly implementing what people request or reject in a design. An experienced and authoritative designer is needed to assess the feedback received and determine what would suit the functionality of the design the best. This is discussed in greater detail under participatory design (See 2.4.1). This also ties into the level of expertise of the problem-solver, which is discussed in detail in Chapter Three.

A criticism of human-centered design is that it has the potential to be a top-down approach where design professionals collect requirements and determine the needs of the target population before developing products or systems to address these needs (Norman & Spencer 2020). However, when the human-centered design approach is properly considered, participants are interviewed and invited to give feedback, to avoid this kind of bias that could result in unsatisfactory solutions.

As with any design philosophy, it is important to consider the ethics involved when utilising it. Richard Buchanan (2000:4) maintains that designers have a moral imperative to consider whether the products they are creating support human dignity or not. Human-centered design certainly does lend itself to supporting human dignity as it gives end-users a voice in the process, but this can also easily be abused.

2.3.1 Design and business – design for business' sake

Human-centered design can be utilised as a business strategy. It is no longer enough for a business to have cutting-edge technology. It is imperative to consider how people interact with their products or services. Eric Von Hippel (2005:28) of the MIT Business School analyses this shift in mindset statistically, and notes that, "70% to 80% of new product development that fails does so not for lack of advanced technology but because of a failure to understand users' needs." Jacob Nielsen (1993:74) expresses a similar view, observing that "much time is wasted on certain development projects by arguing over what users might be like or what they may want to do. Instead of discussing such issues in a vacuum, it is much better (and actually less time-consuming) to get hard facts from the users themselves."

This points to design being a "product" and a "business process" rather than a valuable procedure in its own right. IDEO (2015:14) proposes the Venn diagram as in Figure 5 to show how to approach design problems.[16] It suggests that we start by looking at human wants, needs, fears and hopes, in order to determine what is more desirable. After this, a variety of solutions may be created to serve the community. These then need to be examined through the lenses of technical feasibility (does the technology exist to do this, and can we do it within the technical constraints we have?), and business viability (is it going to make money for the company?). IDEO proposes that an ideal solution lives in the centre of this Venn diagram – the grey dotted area – where all three are considered equally.

[16] Design problems are discussed in-depth in Chapter Three to understand how they are structured and formulated in the first place.

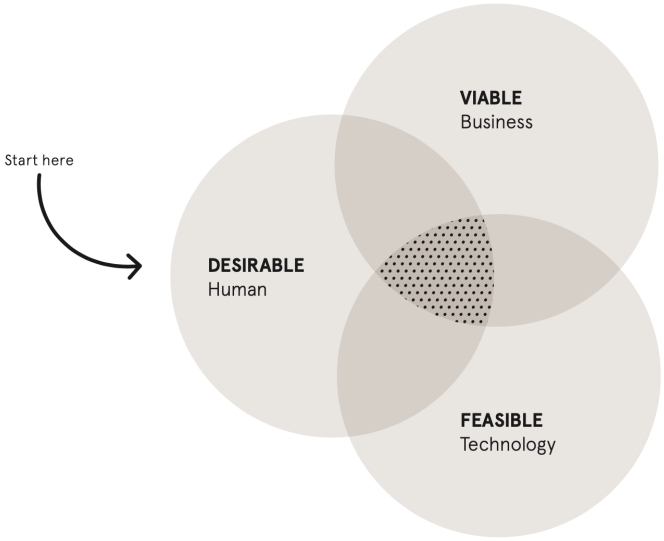

Figure 5: Venn diagram of human-centered design. (IDEO 2015:14).

While it may be true that the adding of the "human" element should lead to more successful business implementations, there are many enterprises that do not but nevertheless enjoy great success. Consider "ad tracking" on websites, it is invasive, tracks data without consent, and poses concerns about privacy, and yet it is widely accepted and used because it is possible and makes "business sense." Another example is budget airlines constantly reducing seat sizes and leg space – thus making the travelling experience more and more uncomfortable for passengers. They are constantly walking a tightrope between keeping business viable while not tipping over into "non-desirable". There is also the case of so-called "grudge purchases" – things you may not *want* to buy but need, such as car insurance or funeral cover.

In this Venn diagram, *ethics* is conspicuously absent. Design without ethical considerations can easily slip into questionable patterns that may benefit the business, but not the customers nor consumers not even the environment. Ethics might also be implicit in this diagram as many other aspects are also absent. "Desire" is also represented as the epitome of what humans should strive for – not "what is good", or "what will benefit humanity" - which reflects a problematic utilitarian outlook. No matter how desirable and feasible a product or service may be, if it is not a viable business model, no company will invest in it, because no money would be made. This leads to the conclusion that human-centered design will always be *subordinate to business decisions.*

In 2018 IBM commissioned Forrester Consulting ([sa]) to conduct a Forrester Total Economic Impact™ Study to investigate the business case for their *Enterprise Design Thinking* process. The impact study shows that it cuts $20.6 million in costs for customers by accelerating projects, and saves $18.6 million by reducing risk and increasing portfolio profitability. It ensures that projects get to the market twice as fast, design time is reduced by 75%, and software development time by 33%. IBM also advertises a

300% return on investment (Forrester Consulting [sa]). While those are impressive statistics, the question remains whether that is true specifically for IBM, or whether the results would be similar for any design thinking process that is implemented.[17] The fact that IBM commissioned this study demonstrates the importance of showing the business value of design to non-designers in tangible, quantifiable metrics and words that relate to business. However, because it is qualitative by nature, design is difficult, if not impossible, to quantify. The value of human-centered design is similarly difficult to quantify. How does one express the value of a parent not seeing their child in distress, as in the case of patients that engage with Doug Dietz's Adventure Series? It can be measured in reduced costs for the hospital and reduced fees for patients, but seeing a patient smile and not cry in fear, is not something that can be measured. Human-centered design looks at improving the quality of life in many aspects. This quality cannot easily be reduced to something quantifiable. The fact that more and more design metrics are measured in quantifiable aspects is something that design practitioners should be aware of, and wary of.

Natasha Jen (2017) believes that design processes and the way we speak about them (Figure 6) have become corporate jargon that people in business want to hear. They have become a box to tick to say companies are "design-focussed", "design-led", or that they incorporate "design thinking". This is considered *"design-washing."* It refers to performing design-related activities only superficially with no expectation of actually gaining insight or value (Mueller 2020). This mirrors a frustration in radiology, where radiology reports run the risk of also just being a 'tick box' in terms of 'tests' to be performed by physicians.[18]

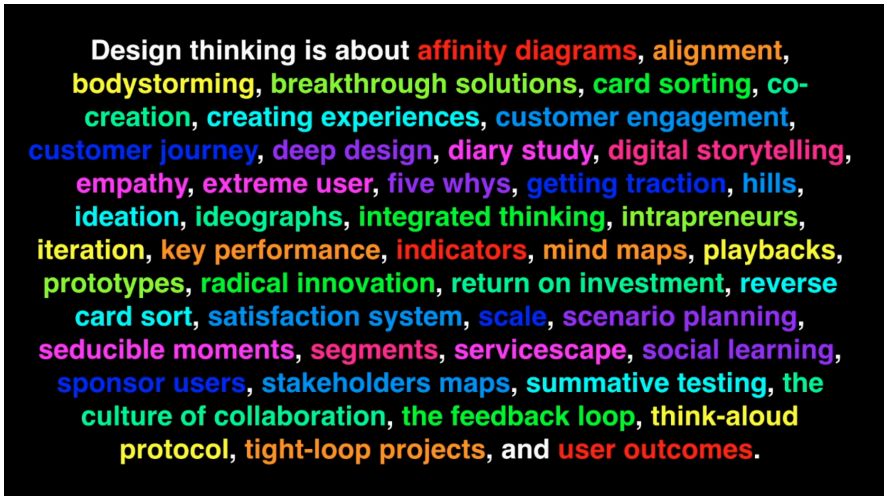

Figure 6: Design jargon, *Natasha Jen: Design Thinking is Bullsh*t*, 2018. Screenshot by author.

[17] Other design thinking processes are discussed in the next chapter in order to compare their similarities.
[18] This is discussed in more detail on page 152.

2.3.2 Design for design's sake – Community intervention as harmful

Creating solutions for the sake of satisfying a business objective is not ideal, but neither is creating without fully considering all of the contexts. Many solutions that may at first appear to be human-centered can quickly fall short once implemented.

The first example to consider is that of *PlayPumps*. This initiative was founded in 2005 by South African entrepreneur Trevor Field. The idea is illustrated in Figure 7. As children play on a merry-go-round (1), water gets pumped to a reservoir tank (4), and water is then available through a tap (5). The US government pledged $10 million towards the initiative, with another $18 million from other donors. American hip-hop artist Jay-Z even made an MTV documentary about visiting one of the sites, and also hosted a fund-raising concert.

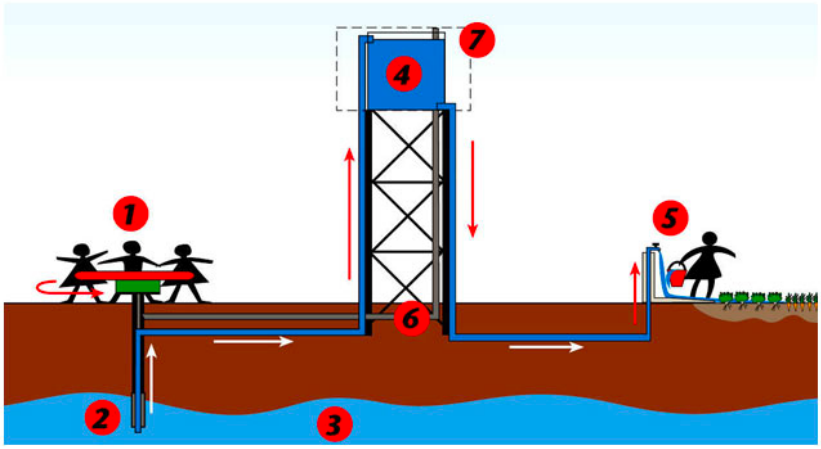

Figure 7: Diagram of how Playpumps work. PlayPumps website, 2010.

At first glance this project appears to be a good example of human-centered design in practice. It is focussed on the community by providing both entertainment and accessible drinking water.

Reporting on this initiative five years after it was initially launched, Costello (2010) found that the pumps were much less successful than anticipated. In more rural areas where children were less prevalent, older women struggled to turn the merry-go-rounds in order to pump water: "…the old hand pumps were much easier, … no-one consulted [us] about the change." There were also issues with pumps not being maintained. After installation, little to no money and other resources were allocated for upkeep. Some pumps were out of commission for up to 17 months whilst waiting for parts. It also came to light that many of the sites chosen for installation were unsuitable, and frustrations were slow to be addressed, or ignored completely. In the end, most of the PlayPumps were abandoned and later removed in favour of hand pumps that were re-installed, in line with what locals wanted.

This initiative was, in the end, not human-centered at all. The community that they were seeking to help was never consulted, and no effort was taken to understand their needs. Most did not mind the original hand pumps in the first place, but were not consulted prior to the decision to replace the pump was made.

2.3.3 Human-centered design as anthropocentric

Anthropocentrism "[regards] humankind as the central or most important element of existence, especially as opposed to God or animals" (Oxford English Dictionary 2021b). Considering the first word in this design philosophy is "human", it immediately points to placing humans front and centre when design solutions are created. While this is the intention, it also highlights a blind spot regarding the rest of the world. Humans do not live in isolation. We live in ecosystems, many of which are in danger due to human intervention and destruction. Thackara (2020) addresses this later in this chapter in the section on *Life-centered design.*[19] Anthropocentrism raises the problem of being "individualistic" at the expense of others and the environment.

The Uber experience

Uber, the e-hailing service provider, is often heralded as an excellent example of human-centered design. Their apps are intuitive and easy to understand and use, and their service offering fills an important gap in the market regarding safety and being able to determine pricing of services upfront. An aspect that is rarely considered is how they actually treat those people who work for them. In the case of Uber drivers, in most countries they are not technically employees, but rather similar to contractors. This is certainly the case in South Africa. This means that most labour laws do not apply to them. There is no protection in terms of minimum wage, overtime, or mandatory holiday pay. In 2021 two South African law firms announced that they would initiate an opt-out class action lawsuit against Uber on behalf of South African Uber drivers, in order to have them classified as employees and secure these benefits. This came shortly after the UK Supreme Court ruled that Uber drivers should be classified as workers and qualify for benefits (Magubane 2021). The experience of this company from the point of view of drivers is certainly not human-centered. The question is who is human-centeredness meant to be aimed at? Is it sufficient to only be consumer-facing? I would argue that a company should be holistically human-centered. One cannot offset unethical practices in one part of a business by "putting people first" in another aspect.

[19] Design systems should consider not only the people who use them, but also the environment, sustainability, and their lifestyles. Design does not happen independently of these systems.

The Airbnb experience

Another business that is considered contentious by some is Airbnb. Their business model allows people to rent out their properties as accommodation to others for holiday stays or business trips. Their motto is “live like a local”, and when travelling to a new country or city this can be attractive as it allows one to experience what a local home would be like. However, this practice does not benefit everyone. A report released in 2014 by the New York state attorney general’s office states that as many as 72% of Airbnb listings in New York City could be illegal. These listings could be skirting taxes, as these homes are not registered as hotels, neither are they paying hotel taxes (Glenza 2014). This affects the city negatively. Another effect that Airbnb has had on cities is that it can cause real-estate prices and rent to soar, making it difficult for locals to continue to stay in certain areas. The mayors of Venice and Florence in Italy sent a “Decalogo,” a list of ten commandments, to the Italian government in 2021. One of their demands is to limit Airbnb. They state that, “The short-term rental phenomenon needs to be better managed with clearer rules nationally," as some people “hide a business behind a rental” without being subject to the same regulations as the hospitality sector. Rental properties also pay far less tax than B&Bs and hotels – 21% compared to 60% – which means they can easily undercut registered businesses. Rentals also "encourage the emptying-out of historical centres because of the surge in costs of renting over medium- and long-term periods” (Buckley 2021). Again, while this business model may be beneficial to tourists and the people who use Airbnb, little thought has been given to how its practices affect the inhabitants of the same cities.

On the other hand, in an effort to help those in war-torn Ukraine, Airbnb recently offered the use of their platform for good. People can book an Airbnb stay in Ukraine with no intention of actually going. Therefore the funds go directly to the hosts without any platform fees attached, essentially as a donation directly to the hosts. By mid March 2022 people had booked more than 434 000 nights in cities like Kyiv, Odessa and Lviv, amounting to more than $15 million in humanitarian aid (Pardes 2022). However, in mid-March Airbnb stopped allowing new hosts to create listings in Ukraine, in an effort to minimise scams. Ben Breit, the global trust communications lead at Airbnb states that Airbnb “ … identified a handful of hosts who did not support this effort in the spirit intended.” In other words: some hosts created “ghost listings” for apartments in Ukraine that did not exist. In some cases the hosts did not live in Ukraine at all. Breit suggests donating directly to Airbnb.org, which is committed to providing free, short-term housing for 100 000 refugees from Ukraine (Pardes 2022). Stays with hosts that Airbnb deemed suspicious were cancelled by the platform with no prior communication, and it is impossible to know how many legitimate listings were cancelled, and how many scams succeeded (Pardes 2022).

The online shopping experience

Another example of design that can be considered anthropocentric is that of online shopping. It is fast, easy, reliable, and the intuitive interfaces have ensured that customers usually have pleasing online shopping experiences. It is human-centered in that it prioritises the comfort and ease of the person who is shopping. However, an environmental study conducted in 2020 indicates that shopping for fast-moving consumer goods online results in much higher levels of greenhouse gas emissions from delivery vehicles as opposed to conventional shopping in a physical store. There are various reasons associated with this but among others, customers tend to buy a few items from various stores while buying online, whereas when buying in person they tend to buy from fewer stores (Shahmohammadi *et al* 2020). The environment suffers, although it is supposedly human-centered.

There are complexities to the above examples. They are mentioned briefly to show that being human-centered is a lot more complex than simply having an intuitive interface or only considering the people you design for. It is also not enough to design for some people but not for others. All in all, human-centered design is an *intention* that should permeate the entire design process. It should be considered in all aspects. However, while it is important to strive for an ideal, it is more important to get a lot right than to be perfect.

2.4 Approaches to human-centered design

Within human-centered design, there are various approaches that may be used to address a problem and find a solution. While they are discussed here as separate and different for the sake of explanation, in reality there is much overlap and similarity between them. This exploration and comparison of human-centered design approaches serves as the third objective towards establishing how human-centered design can be utilised in a South African context. There is strong emphasis on the approaches themselves, which has the potential to undermine the entire design process by shifting the focus from *finding solutions* to the *approaches themselves.*

Sanders and Stappers (2008) map the overlaps in human-centered design approaches in Figure 8. They consider the main tensions to be:

a) between the "user as subject" and the "user as partner" as one axis[20],
b) and "led by design" and "led by research" as the other.

[20] In an earlier publication of the same diagram, Sanders (2006) uses slightly different language to describe the axes:

a) "Expert Mindset – 'users' seen as subjects (reactive informers)" vs "Participatory Mindset – 'users' seen as partners (active co-creators)" and
b) Design-led vs research-led

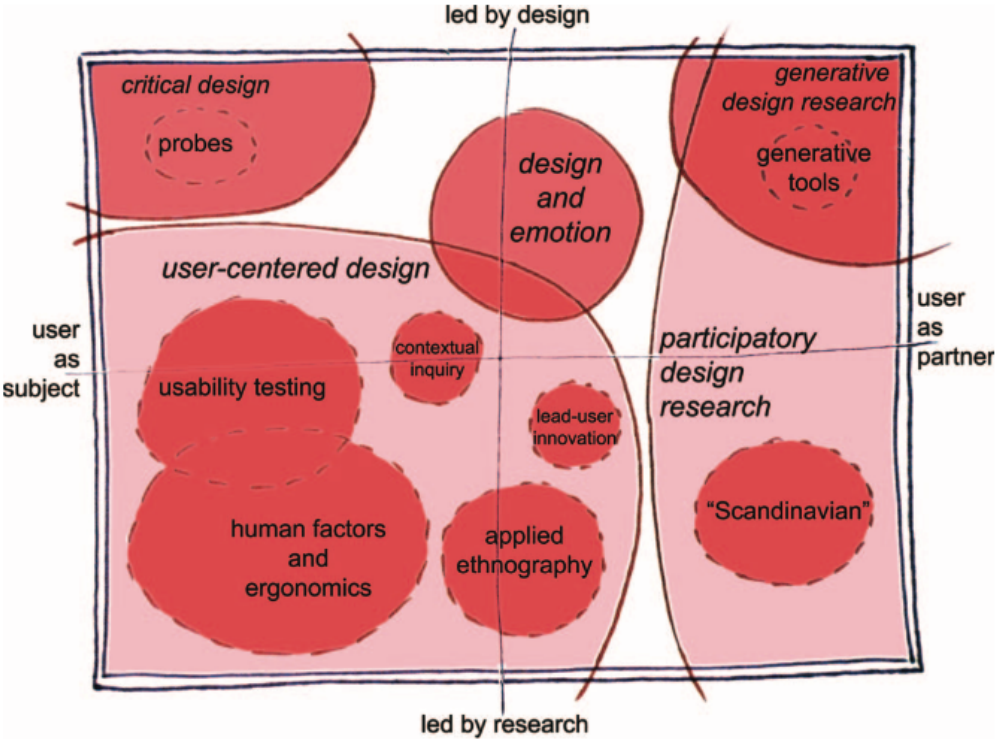

Figure 8: The landscape of human-centered design research as practised in the design and development of products and services. (Sanders & Stappers 2008).

Steen (2011) uses the previous diagram as inspiration, and builds on it to map the overlap of six different approaches to human-centered design (Figure 9). These convey how each relates to what he considers the two main tensions in human-centered design:

a) between designers and users – combining inherent knowledge with expert analysis and opinions, and
b) between what *is* and what *ought to be* – as human-centered design aims to both understand and incorporate the past and current, as well as design for the future.

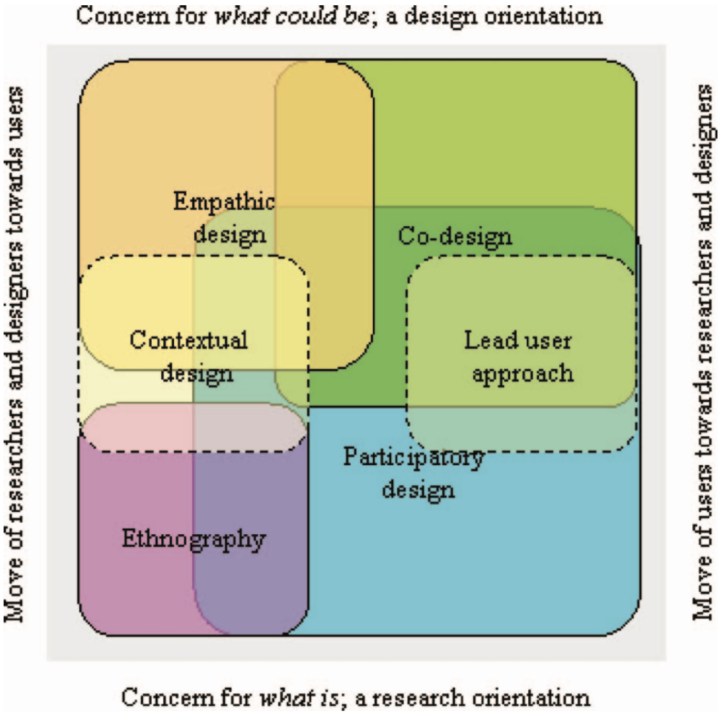

Figure 9: Different human-centred design approaches, with different starting points and emphases. (Steen 2011).

In both Figures 8 and 9, the capacity in which people are involved in creating solutions accounts for one of the "points of tension", or axes. On one side, we see the designer as the lone expert who investigates and considers feedback, and on the other we see the designer working collaboratively with others to create solutions. The designer is no longer a sole expert, but becomes more of a facilitator.

In both diagrams, the y-axis represents a tension between design and research, although Steen (2011) includes the emphasis that design focusses more on what *could be,* whereas research focusses on *what is*.

Both of these diagrams rely on a two-dimensional mapping of the approaches, with only the main tensions that Steen (2011), Sanders and Stappers (2008) consider as the mapping points. Design and its approaches are not a straightforward or linear process and, conspicuously, concerns such as ethical considerations and client involvement are omitted. The person being designed for (the end-user), is rarely the person paying for a project. I suggest that mapping different human-centered design approaches would be more accurate in a 3, 4, or even 5-dimensional space, due to the many complexities that are not currently represented. However, since this research project does not intend to veer off into the fields of physics or mathematics or the feasibility of 5-dimensional space, it will instead concentrate on the actual approaches mentioned, as well as other approaches that are prevalent in human-centered design today.

I explore nine design approaches in depth, their advantages and limitations, their application in a South African context, as well as a healthcare context, and finally in relation to this study. This lays the groundwork for Chapter Four, where a case study is conducted. The nine approaches to be discussed are participatory design, co-design, community-based design, user-centered design, activity-centered design, ethnography, a lead user approach, contextual design, and empathic design. Two emergent approaches that are worth noting but not yet prominent in academic discourse are also briefly mentioned.

2.4.1 Participatory design[21] approach

In the 1970s in Scandinavia, academics upon realising the potential for worker emancipation and establishing democratic values in the workplace through the introduction of computers and automation, collaborated with trade unions (Steen 2011:49; Greenbaum & Kyng 1991; Törpel 2005). This was pioneered by Kristen Nygaard and the Norwegian Metal Workers' Union. It was considered a "work-oriented design approach", and later renamed "participatory design" . The idea of a "democratic workplace" implies that people should have the right to particulate in decisions concerning their lives (Ehn 2017). "Participatory" is defined as "characterised by or involving participation, especially: providing the opportunity for individual participation" (Merriam Webster Dictionary 2021). Thus participatory design represents an approach in which "the people destined to *use* the system play a critical role in *designing* it" (Schuler & Namioka 1993:xi; my emphasis).

Advantages of participatory design

Three features are especially noteworthy:

1. *Pragmatically* it fosters an environment where people feel comfortable expressing their ideas and offers an opportunity to create systems that work better appropriate to their specific contexts. (Greenbaum 1993; Gregory 2003; Press and Cooper 2003)
2. *Theoretically* it enables designers and researchers to understand the lived experiences of those they are creating for, drawing on their tacit knowledge to identify design problems and solutions. (Greenbaum 1993; Gregory 2003; Van Zyl 2006). It allows designers, researchers, users, and other stakeholders to engage in mutual learning which enables them to jointly create solutions (Spinuzzi 2005; Steen 2011; Ehn 2017).
3. *Politically* it empowers people - "people have the right to influence their own workplace" (Greenbaum 1993) - who become active participants in the solutions created. It also allows the

[21] While the terms *participatory design* and *co-design* are sometimes used interchangeably, they are different and have different origins that will be discussed separately. Co-design is discussed later in this chapter.

participants a sense of ownership in the new design solution (Press & Cooper 2003; Van Zyl 2006). This ownership makes people less reluctant to embrace change (Gregory 2003).

Ehn (2017:73) notes that real engagement requires a "shared form of life" – a shared cultural and social background, along with a shared language. The intention is not only for users to participate in design, but also for designers to participate in *use.* Participatory design is therefore intended to transcend superficial engagement and foster deep interaction, understanding, and empathy.

Limitations of participatory design

Although there is certainly merit in asking the community or direct stakeholders to participate in designing a solution, there are also potential pitfalls. A quote by car manufacturer, Henry Ford, often mentioned when user-experience research is discussed, states, "If I had asked people what they wanted, they would have said faster horses." While there is no proof that Ford did indeed utter those words (Vlaskovits 2011), it does open the discussion regarding possible imagined solutions. It is not generally reasonable to expect people to solve problems concerning products or spaces that they had no hand in creating. For this reason Braa (1997) suggests that it is more useful to provide participants with prototyped solutions and ask them for their feedback.

The knowledge that people may have relating to a problem may also be localised, and the suggested solutions from participants may focus on symptoms, not underlying problems (Norman and Spencer 2020). It is more useful to understand what the actual problem is – in Ford's case, people wanting to travel from A to B faster – than it is to ask them to imagine those solutions. It also binds people to what they can currently imagine and their existing frame of reference, when asking them to speculate on future behaviour (McKay 2020). Another criticism is that optimising a localised process may not lead to a globalised optimisation (Norman & Spencer 2019). Optimisation in itself is an odd metric to use with regards to design. Systems and processes can be optimised, but while processes, such as user experience (UX) design, can be more objective according to best practice, it is still a difficult thing to 'prove', which is in part what makes that one can consider something 'optimised'.

Steen (2008:27) addresses this criticism by stating that people are not expected to solve the problems, but rather to contribute to research as experts on their own daily lives and in the way they have experienced products and services. Adding to this, Norman and Spencer (2020) suggest that, when applying human-centered design, additional considerations need to be added when dealing with the major complexities of the world. Prominent areas in this regard are, firstly, a consideration for "large complex, sociotechnical systems," suggesting the intersection of political, social, economic and cultural variables. Secondly, understanding is paramount. Whilst automated technology can provide answers

quickly and easily, it is often difficult to understand how these answers were derived, both for professionals and affected people. Lastly, cultural sensitivity needs to be taken into account. Solutions must be sensitive to beliefs, culture and history. For anything this complicated, involvement from the local community will be useful. However, this does open the door to lack of sensitivity to cultural contexts, or misappropriation of local culture.

Participatory design also requires commitment not only from the designer(s) in the process, but also the other stakeholders as well as participants and those affected. Time needs to be made available to participate in more labour-intensive methodologies such as workshops, interviews, focus groups, contextual inquiries, journal keeping, and interactive meetings.

Participatory design in a South African context

Participatory design is a popular approach in South Africa and indeed in many developing countries. The reason for this is threefold: it empowers participants, encourages participation, and allows for a bottom-up approach (Braa 1997). As briefly mentioned earlier, Ria Van Zyl (2006) led a multi-disciplinary team in reimagining rural transportation solutions during Interdesign 2005 in the North West province in South Africa. While "participatory design" is not explicitly mentioned, the approach of the project was to involve the community directly and encourage collaboration.

During interactive research workshops, students from Grades 10 to 12 were presented with the design problem and asked to draw their own ideas of how their transport problems could be solved. By taking this approach, students drew on lived experiences, not necessarily creating new innovative solutions, as one would create with generative tools during co-design. The solutions that students offered (Figure 10) fell into one of four categories: firstly drawings showing aspirational and functional needs. Secondly, drawings showing how solutions could be constructed and how materials could be used. Thirdly, drawings showing socio-economic expectations, such as improved infrastructure in the form of tarred roads, public transport, and money being more readily available to pay for transport. Lastly, some drawings showed alternative solutions such as Segways, rocket scooters, jumping shoes, or fantasy self-propelling vehicles.

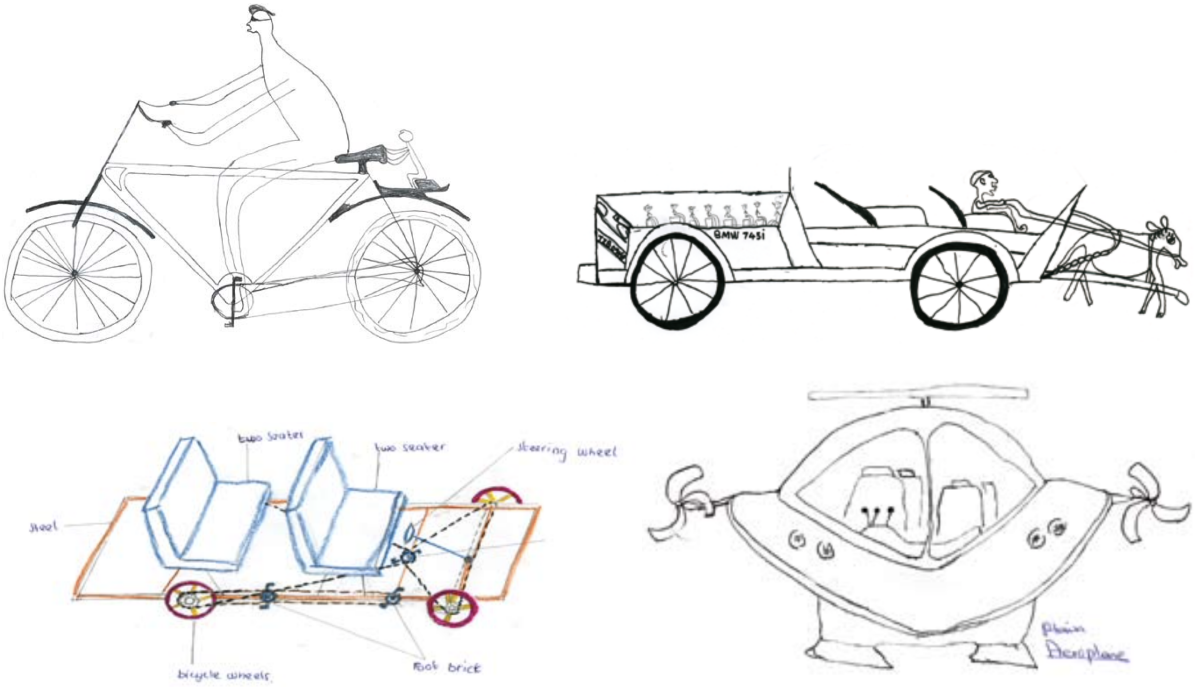

Figure 10: Student drawings from each of the identified categories during Interdesign 2005. (Van Zyl 2006).

The use of involving the community in creating solutions moved them from being merely a source of background information to becoming active participants in the design process. It afforded designers and researchers a greater understanding of the context within which people were experiencing travel, and allowed them to understand their lived experiences. Most designs were improvements on existing solutions, not necessarily innovative, creative new ideas – this is one of the constraints of participatory design. [22]

Participatory design in healthcare design

This is where we focus on an example applicable of participatory design in South Africa. Between 1996 and 2001, the Systemarbeid (System Development) group[23] undertook the revision of the Health Information Systems Project (HISP) in South Africa. This was done in collaboration with medical and computer science faculties in Norway, South Africa, and Mozambique, as well as the Departments of Health in South Africa and Mozambique (Gregory 2003). The aim of the project was to create a system that enabled more efficient use of local resources, which would in turn result in better healthcare, and better health for the population. Rapid prototyping was used to quickly test solutions with

[22] While a constraint, if an idea solves the issue at hand, it need not necessarily be novel. Here the concept of "satisficing" by Cross (2004:434) applies: the idea that design experts often look for 'satisfactory' solutions, instead of ideal ones.
[23] The Systemarbeid (System Development) group of the Department of Informatics, University of Oslo was founded by Kirsten Nygaard, who also pioneered the participatory design approach in the 1970s between factory workers and unions in Norway.

participants. This brought informal feedback and kept design decisions open - two aspects that were deemed vital for the project.

Key insights from this project were that the local initiative should be taken towards developing the system. It should be driven from 'within', and at least one person should be committed to driving the process and the development of a new system. This again speaks to the 'ownership' as discussed in the motivations to using participatory design.

Participatory design with regard to this thesis

There are numerous aspects inherent in participatory design that lend well to the application of this thesis, specifically relating to collaboration between subjects/stakeholders and the designer (myself). However, as can be seen in both the *Interdesign* and *HISP* examples mentioned above, true participatory design requires intensive input and collaboration from participants. From the beginning I had concerns about the time participants would be able and willing to part with (since doctors are busy people), and as the project progressed it became clear that a fully-immersive project in collaboration with these particular subjects would not be possible. Unforeseen aspects also came into play, such as the Covid-19 pandemic, about which more is said below.

Expected difficulties for both radiologists and registrars[24] included availability and time, for similar reasons. Both groups work full-time jobs and are on call occasionally – meaning they work through the night or over weekends to deal with emergency cases that may be brought in. Registrars have the added pressure of also being students who need to study and write exams every few months. Above and beyond this, both groups lead lives outside of their work and studies, which might include family responsibilities, hobbies, time to relax, etc.

Initially, as an ideal study, the research methods that were considered for the study included contextual inquiries, one-on-one interviews, focus group discussions, context-of-use analyses, task analyses, a one-month diary-keeping exercise, an existing system analyses, and competitor system analyses.

After taking doctors' availability into consideration and not wanting to impose too much, I chose to keep participation in research minimal with methodologies chosen as a one-on-one interview, a focus group discussion, as well as a two-week journal-keeping exercise. The focus group discussion was removed from the methodology after concerns voiced by the University of the Free State's ethics

[24] A reminder: registrars are fully qualified medical doctors who are continuing their studies – obtaining master's degrees – to become qualified radiologists.

committee around potential harm of reputation to registrars, as well as potential discomfort discussing their working environment or frustrations they may have, with their peers. The ethics committee was concerned about the potential for embarrassment surrounding issues that might be personally sensitive, and possible judgement or ridicule afterwards.

The principal unforeseen circumstance that affected this study was the emergence of Covid-19, and the resulting global pandemic. For this reason the contextual inquiry had to be removed from consideration, as Covid-19 restrictions in South Africa ensured that I would not be allowed into the hospital as a non-staff member. Interviews were thus conducted via video-conferencing software. After realising that registrars write exams every few months while working full-time, and, considering that different student years write at different times of the year (meaning the registrars who are not writing at that time pick up the additional workload for those who *are* writing at the time), and that this is essentially a constantly rotating schedule, I also chose to remove the two-week journal-keeping exercise. Instead focus was placed on getting insights directly from registrars via interviews.

I was in contact with the Head of the Department of Diagnostic Radiology at the University of the Free State from April 2021 to secure time to talk to registrars. It took nine months of discussion before I was able to interview them. This was partly due to the constraints imposed by the ongoing pandemic, and the medical exams throughout the year that registrars needed to write. Another restriction was availability due to registrars leaving and new ones starting. When I was eventually able to interview registrars, I allowed them to book time slots over weekends, and from 09:00 in the morning until 22:00 at night. 70% of the interviews took place in the evening after 5pm in the afternoon or over weekends, at the registrars' request. Interestingly, some registrars chose to interview 'post-call', i.e. on the day they have off after being on call the previous night.

In adapting the research technique to suit my subjects better, I was inadvertently following a human-centered design approach by taking them into consideration and ensuring their comfort above all else. It did not occur to me until much later that I had unintentionally changed my study methodology to be more human-centered, shaped by the circumstances of the people who would form part of the study. As a designer and specifically as the head of a user experience (UX) and user interface (UI) design department that utilises a human-centered design approach for all our design projects, it has become second nature to consider the human actors in a process. It is likely that I would have gained different insights if I had been able to follow my initial methodology to the letter, but that also carried the high risk that registrars would not have participated in the study at all if they felt it would be too time-consuming. It was vital to get real insights from the people working in the environment, otherwise the study would only consist of assumptions about their working environment, frustrations and pain points - the very things that human-centered design aims to mitigate. In a typical human-centered

design situation, the designer would be commissioned to do a specific job or address a specific problem. In this instance, however, I initiated the research, and inquired whether the department would be willing to participate. It should be noted that the aim of this research is slightly different because it is geared towards employing "designerly" ways of thinking to interpret, understand, and speculate on possible ways to address the concerns of a specific problem space, rather than implementing and testing any solutions. If the research had been commissioned by the Department of Health or the diagnostic radiology department, it is likely that I would have faced less constraints in the practicalities of the task and, because of these constraints certain aspects of the methodology had to be rethought.

For the purposes of this study, a participatory approach where co-creation is involved was thus deemed too time-intensive for participants. The process remained very much research- and design-led, but used other methods, primarily interviews.

2.4.2 Co-design approach

The next approach to be investigated is considered by some to be a contemporary form of participatory design, which also incorporates tools and techniques from other fields similar to the visual arts (Steen 2011:52; Sanders & Stappers 2008). This approach has largely been pioneered by Elizabeth Sanders and other collaborators. The prefix "co-" is defined as "with, together, joint, jointly" (Merriam Webster Dictionary 2021). This approach aims to facilitate users, designers, researchers and other members to cooperate creatively to create solutions.

Sanders (2000) believes that in order to move towards a new future, "everyday people" will need to be brought into the centre of the design process, i.e: a people-centered process. She proposes "generative research" for this process. This is a method to allow people to make and envision their own futures. It is most often a toolset that allows for the creation of a shared design language between designers, researchers, stakeholders, and end users (Sanders 2006:6). What makes it generative is the possibility of expressing an infinite number of ideas through a limited set of items. It is focussed primarily on non-verbal modes of expression, using toolkits to allow people to 'make' in order to create their thoughts, feelings and dreams. This is in contrast to traditional design research that has focussed mostly on what people do and use, as well as traditional market research that has concentrated, by means of focus groups and questionnaires, on what people say and think (Sanders & Dandavate 1999). These different levels of engagement can be seen in Figure 11.

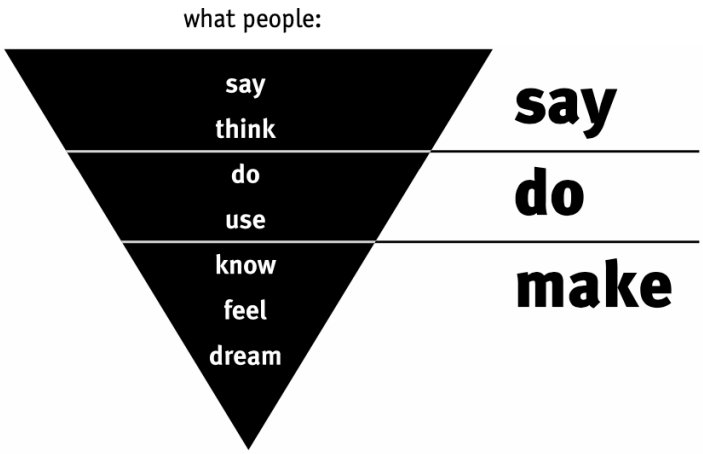

Figure 11: Diagram showing different levels of human experience. (Sanders & Dandavate 1999).

Sanders and Stappers (2008:15) believe that designers will still be vital to the design process in the future, since designers possess "expert knowledge" (not accessible to other stakeholders) that allows them to guide and facilitate projects. Designers keep track of new, existing and emerging technologies, and also have an overview of business contexts and production processes. This knowledge will still be relevant going forward, when Sanders and Stappers (2008:15) believe that designers will become more involved in design for environments and systems, not only standalone products.

Advantages of co-design

Non-designers begin to gain skills that can assist in the co-design process, the implication being that they will eventually be able to follow generative design processes without the input from design experts. This leaves them less reliant on specialist intervention. This can also be problematic, as discussed in the following chapter. Co-creation is an act that is regularly engaged in between companies and customers, and touted as part of the product design process (Sanders & Steen 2008). An example of this can be seen in the www.NIKEiD.com website which allows people to customise their own shoes, by choosing colours and detailing. This is done by means of augmented video mapping on a white shoe (Figure 12).

Figure 12 : A customer creating a custom sneaker, London. (Briguglio 2017).

In a world where more and more time is spent on imagining future states, Sanders and Steen (2008:7) believe that design processes are moving towards having a larger "fuzzy front end", as can be seen in Figure 13. During this phase of the design process, it is not clear whether the end result will be a product, a service, a building, an interface, etc. This is especially true when the initial question or brief is not straightforward, but more open, such as, "How can we improve the quality of life for people living with a chronic illness?" Or in the case of this thesis, "How can we improve radiology workspaces in public hospitals in South Africa?"

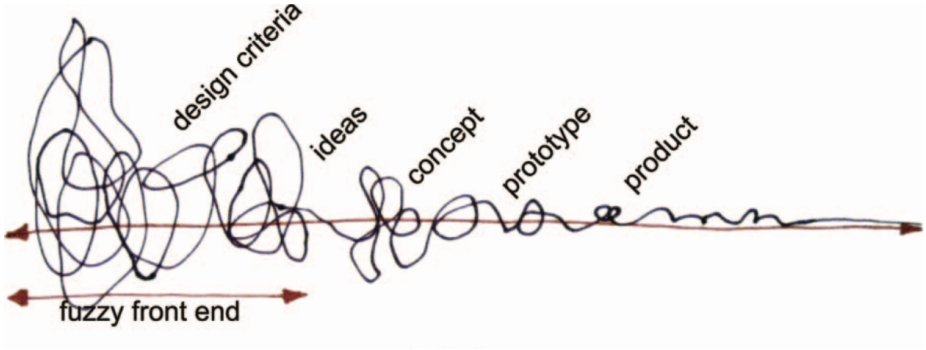

Figure 13: Co-design process. (Sanders & Stappers 2008).

Co-design is thus more concerned with future states and future experiences than current ones, as opposed to participatory design and the lead-user approach, which are more concerned with mapping current possibilities and environments.

Limitations of co-design

Designers are responsible for ensuring the generative tools they provide are appropriate for the context, and selected carefully (Sanders 2000; 2005). By selecting the type of generative tools to be used, the designer may unintentionally influence the results of the study and introduce bias.

Non-designers are required to be creative and exhibit creative initiative. Experienced designers are required to facilitate the process. Co-design also requires existing power structures be put aside and traditional hierarchy and power be relinquished (Sanders & Steppers 2008). Whether this is good or bad is a moot point, but it does present a risk when designers need to arrive at an outcome, especially within a specific time frame and budget.

Co-design in a South African context for healthcare design

Cunningham and Cunningham (2019) examine the co-design of a standards-based solution to be used in resource-constrained healthcare facilities in South Africa, Ethiopia, Kenya, and Malawi. The solution – *mHealth4Afrika* – was created for use on mobile devices, as this addresses a weakness in how technology is used to support patient-centric healthcare provision by healthcare professionals.

The project integrates electronic health records with electronic medical record functionality, medical sensors, decision support tools and data visualisation. It was specifically designed as a cross-border solution based on insights from healthcare systems in different countries. The intention was to create a solution that could easily be scaled and adapted across the continent.

The methodology for this project uses co-design, collaborative open innovation and design research techniques, as well as agile development processes. [25] This allowed the researchers and designers to work closely with policy makers, clinic managers, district health officers, as well as healthcare workers, to validate iterations of the *mHealth4Afrika* platform. By working directly with these decision makers, it was much easier to repeat and consult on solutions regarding functionality, workflow and usability issues.

The project resulted in Android and Windows applications to be used on phones or tablets. These integrate medical sensors to speed up the workflows of nurses and other healthcare practitioners. By using a co-design approach the team was able to get insights directly from the people who would use the application daily, and gain insights that could not be obtained otherwise.

[25] "Agile" is a methodology that originates in the computer software development industry to aid in incremental delivery and quick turn-around times for clients (Agile Alliance 2015).

Co-design with regard to this thesis

For several reasons co-design approach was not deemed possible for this thesis. It was too time-intensive an approach for the registrars, as discussed under participatory design. It was also not possible to re-locate for the purposes of the thesis, as the researcher is based in Gauteng, and the participants were located in Bloemfontein in the Free State. Owing to constraints imposed by regulations stipulated by the South African government and by the ethics committee at the University of the Free State, I was also not allowed to be on-site at Universitas Academic Hospital due to the Covid-19 pandemic.

2.4.3 Community-based design

The idea of community-based design is an extension of various existing approaches, such as participatory design, co-design, and cooperative design (Norman 2020). Norman and Spencer (2019) propose that instead of designers creating solutions for communities, communities should instead be incorporating the creativity around them and create solutions for themselves. Experts should instead become facilitators, and assist communities to realise their own potential through mentoring, workshops and providing toolkits and support.

Community-based design differs from participatory design as it does not share underlying political motivations and can, to some extent, be seen as an extension of co-design. Norman and Spencer (2019) introduce the notion of Myerson's (2017) "scaling down" approach to guide community-based design, with the following guiding principles:

- **Cultivate a participatory mindset, not an expert one**[26]
  Aim to create *with* people instead of *for* them. This ties into Steen's (2011) notion that co-design approaches should be strongly people-led. Scaling-down requires collaborative methods such as co-design, co-creation and experience prototyping. This ensures that real needs are identified and responded to through an interactive and cooperative process, as opposed to trying to shoehorn participants into a specific design method that may not be appropriate.
- **Make the process design-infused, not design-led**
  Instead of using designer-led approaches, aim to get closer to participants through infusing multi-disciplinary processes with design skills such as facilitation, modelling and visualisation for more collaborative, deeper and richer alternatives.

[26] While Myerson (2017) argues against expert mindsets, I would argue that being an expert is not inherently a 'bad' thing. Experts can guide and facilitate, and this should perhaps rather be stated as a "tension" to be considered.

- **Design for people, not personas**
  Personas can be a useful design tool, but also risky. Too often personas are created using assumptions or stereotypes, which are then reflected in the designs that are created. Scaling down requires designers to consider the messy and sometimes contradictory behaviour of real people, instead of abstract ideals.
- **Aim for engagement, not abstraction**
  When designers engage directly with participants during workshops, co-creation activities and consultations, they are able to resist abstraction because they are confronted with the specifics, namely lived experiences and real opinions. It leaves space for complexity, contradiction and the repetitiveness that real life demands.
- **Build on assets, do not just minimise deficits**
  Note what makes people and their situations unique. Strive to enhance people's psychological and physical assets, building on what communities and individual people have to offer.

Advantages of community-based design

Communities understand their own problems and impediments the best.

Limitations of community-based design

The community's perception of a problem can be incomplete, or even erroneous. Solutions that the community devises may address symptoms and not necessarily underlying problems. As with participatory design, it is difficult for people to solve a problem in which they are entrenched, or that they may have even contributed to creating (Norman & Spencer 2019). This approach requires creativity, time and effort from the community.

Community-based design in a South African context

While there are various examples of community-based projects in South Africa – mostly following participatory or co-design approaches – at the time of writing there were none specifically implementing Norman and Spencer's particular sub-category of community-based design.

Community-based design in healthcare design

In February 2016 the Helen Hamlyn Centre for Design at the Royal College of Art in London began to re-imagine the conditions along a 9.6km/6 mile stretch of the River Foyle in Northern Ireland (Myerson 2017:297-298). This area was well-known to locals as a "suicide black spot". The research team explored how to uplift an area with a record of poor mental health, by encouraging residents to transform the riverbank and bridges into a lively and pleasant space.

Through extensive engagement with communities along the river, three goals were identified in their approach: installing physical and soft barriers, as well as increasing footfall. Along the 864-meter-long bridge an art installation – *Foyle Reeds* – was created to create physical barriers without prison-like bars and cages. The lighting along the bridge was also improved. An app associated with the project allows people to "adopt" a reed for a small fee, which allows them to adjust its colour and brightness.

Figure 14: Visualisation of Foyle Reeds by Ralf Alwani and Lizzie Raby. (Myerson 2017).

By including the community when reimagining this space, designers were able to incorporate insights they would not have been privy to otherwise, thus encouraging residents to take ownership of the space created for them.

Community-based design with regard to this thesis

As has been mentioned under the participatory and co-design approaches: while registrars were interviewed to understand their working environments, co-creation was not deemed possible within the time frame of this thesis.

2.4.4 User-centered design approach

"User-centered design" is a broad term that describes design processes where end-users influence the formulation of a solution (Abras *et al* 2004). This term originated in Don Norman's research laboratory at the University of California San Diego in the late 1980s. In 1986 Norman and Draper co-authored a book entitled *User-Centered System Design: New Perspectives on Human-Computer*

Interaction, after which the term became widely used. It entered into the mainstream lexicon after the group Norman headed at Apple in the early 1990s called itself the "the User Experience Architect's Office" (Norman 2013:xiv).

Norman further expands on the concept of user-centered design in his seminal book *The Psychology of Everyday Things*, which was originally published in 1988. The book has subsequently been renamed and republished 25 years after the initial publication and is now called *The Design of Everyday Things* (Norman 2013). According to Norman (2013:xii-xiii) the revision was required because of the leaps in technology (examples had to be updated from slide projectors to smart phones), the emergence of human-centered design (in part *because* of the first book), and a need to include discussions around aspects that affect experience, such as emotion, aesthetics, enjoyment and pleasure.

Norman (2013:72-73) proposes seven fundamental principles for designers to follow to ensure they make solutions as user-friendly as possible. These are:

1. **Discoverability.** This allows users to establish what actions are possible, as well as the current state of the device.
2. **Feedback.** Users know what is happening in the system. After every action it is clear what the new state is.
3. **Conceptual Model.** There is enough information instantly available to form a thorough conceptual model of the system, which leads to understanding and a feeling of being in control. This enhances the evaluation of results as well as discoverability.
4. **Affordances.** Subtle hints as to what actions can be performed with a specific interface element or product feature.
5. **Signifiers.** This ensures discoverability and communicates feedback effectively.
6. **Mappings.** The effect of actions, controls and their consequences can be clearly understood. Spacial layout and hierarchy often play a role in good mapping.
7. **Constraints.** By not allowing users to perform incorrect actions, it guides actions and eases interpretation. These constraints can be logical, physical, semantic or cultural.

These principles are also echoed by Schneiderman's (1987) "eight golden rules" for interface design. Jacob Nielsen[27] later adapted and popularised these principles and rules to create heuristics for usability engineering – later titled *Usability Heuristics for User Interface Design*.

Considering the name of this approach centres around users, it is valuable to determine who specifically this refers to. According to Abras *et al* (2004) users are the "people who will use the final

[27] Nielsen and Norman started a company together in 1998: the Nielsen Norman Group (NN/g). The company is considered among the world leaders in research-based user experience design.

product or artefact to accomplish a task or goal". These are considered the *primary* users, but there are also *secondary* users: those who occasionally use the artefact or use it through an intermediary, and *tertiary* users: those who will be affected by the artefact or make decisions around its purchase (Eason 1988).

In academic discourse there is an ongoing debate between the terminology of "user-centered design" versus "human-centered design". As the above paragraph infers, Norman, Schneiderman and Nielsen all discuss user-centered design in the context of interfaces. For the purpose of this thesis the term "human-centered design" is thus preferred for, as Grudin (1990, 1993) states, "user" is a techno-centric term and it is only from the "perspective of the technology that a 'user interface' is needed". The term "user" limits an issue to the specific interaction (user and interface) as opposed to the total environment that the person is experiencing. "Human-centered" is intended to place more focus on the person themselves in their environment to mitigate against anthropocentrism.[28]

Kelly and Matthews (2014:354) expand on this concept. They state that while user-centered design has become a valued approach to design, an "evolution in the concept of the user" is necessitated. By considering people within the context, products and systems they interact with, a more holistic appreciation of the design problems is possible. Steen (2011:45) also expresses a preference for the term *human*-centered design as opposed to *user*-centered design, as the first focusses on *people,* rather than people's roles in a system. The second may lead to designers, even unintentionally, dehumanising those they are designing for. Too often designers have a tendency to reduce people to the roles that they play in the landscape being designed for. For example, "consumers" when they shop, "customers" when they buy, and "users" when they interact with objects (Sanders 2000). Considering the participants in this thesis do not fall into any of those categories, their designations will instead be referred to when possible, e.g. registrar, radiologist, etc.

Gasson (2003:41) adds that, "user-centred system development methods fail to promote human interests because of a goal-directed focus on the closure of predetermined, technical problems". Giacomin (2014:608) elaborates on this quote by saying that by focussing on a "user", characteristics of the product, system or service are optimised based on preconceived plans and notions.
While usability does form an important part of human-centered design, there is a lot to be considered even beyond ergonomic, sociological and psychological impact. As stated previously, human-centered design should strive to affirm human dignity (Buchanan 2000:5).

[28] This topic is explored in more depth by Akama (2012), Akama *et al* (2020), and Bardzell *et al* (2021).

Advantages of user-centered design

By including the end-users of a product in its design and development, it can be ensured that the product will be suitable for its intended purpose, as well as the environment in which it will be used. It ensures a deeper understanding of the organisational, psychological, ergonomic and social factors that emerge during product design and development (Abras *et al* 2004).

Expectations regarding the new product can also be managed since users have been involved in creating the outcome, so from an early stage they know what to expect from it. They feel involved and that their ideas and suggestions have been taken into consideration. This leads to a sense of ownership that often results in smoother integration of the product into the environment (Preece *et al* 1994; 2002).

Limitations of user-centered design

The biggest drawback to a user-centered design approach is that it can be resource intensive, both in terms of time and costs. It takes time to gather data, conduct interviews, understand people's environments, etc. This in turn can become quite costly. Another potential pitfall is that user-centered design generally benefits from a multi-disciplinary team, such as psychologists, anthropologists and sociologists, which can be difficult to assemble. These team members also need to communicate effectively and respect each other's areas of expertise (Abras *et al* 2004; Preece, *et al* 1994; Preece *et al*, 2002). When immature software products are launched – often referred to as a Minimal Viable Product (MVP) – it actually exploits users and is considered an aggressive innovation strategy suggested by several authors for companies competing in a turbulent market (Keinonen 2010).

User-centered design in a South African context

Adebesin, Kotzé and Gelderblom (2010) evaluate the usability of a non-standard interface design on a *Digital Doorway* (Figure 15). These rugged, custom-designed kiosks contain multiple terminals, each with a metal keyboard. More than 200 *Digital Doorways* have been installed since the inception of the project at schools, community centres and police stations.

Figure 15: A three-terminal Digital Doorway. (Adebesin *et al* 2010).

Adebesin *et al* (2010) conduct a heuristic (expert) evaluation of the system, and also conduct usability tests, to compare findings. Each method uncovered findings that were overlooked in the other method. By combining them, a holistic view of improvements to the system could be revealed.

User-centered design in healthcare design

Dreier (2012) investigates whether best practice in user-centered design applies to developing countries, in particular South Africa. The interface that is designed and tested is for a portable ultrasound device for midwives in Norway and South Africa. Dreier initially designed the solution in Norway using the ISO 9142-21 design model. This is discussed under different design processes in Chapter Three under 3.2.8 (page 93). He then conducts usability testing on the interface in South Africa – particularly in rural clinics in Kwazulu Natal.

Several modifications were made to the prototype following the testing, including making the "exit" button prominent on the software, since a patient with a more critical condition could come in at any time, and the midwife needed to be able to exit the system as fast as possible to start an examination of the new patient. Other discoveries were that 50% of the South African participants had never used a computer before, and struggled with using the mouse to click through the prototype. 60% did not know what an interface "button" was. Some participants instead tried to tap on the laptop screen with their index finger as one would a touch screen, as they were accustomed to this action through their smartphones.

As a result of this, the idea of "cultural affordance" came to the forefront. This referred to people who had not been exposed to computers before who consequently did not know that an "X" (a cross) indicated "close". Dreier (2012:57) therefore changed the interface to remove all symbols that did not "speak for themselves" and could require cultural interpretation. The majority of usability issues uncovered for the South African context related back to the midwives being unfamiliar with

computers. It is debatable whether an introductory course to computers, or a redesign of the interface to account for this lack of context would be more effective. Dreier does note that users were eager to learn and learned quickly once corrected.

User-centered design with regard to this thesis

For the purposes of this thesis, participants are not considered in the context of "users", as the term is techno-centric. Registrars were briefly asked about the radiology picture archiving and communication systems (PACS) they interact with daily. Some of the findings around this are included and discussed in Chapter Four. There are definite frustrations around the one application that should be addressed and improved upon. Many of the suggestions came from the registrars themselves, as they had first-hand experience of it. However, this thesis does not propose to redesign or make suggestions regarding improving specialised radiology software, as this falls outside of the scope of this subject.

2.4.5 Activity-centered design approach

Activity-centered design is heavily influenced by "activity theory", an approach that was pioneered by Russian psychologists in the 1920s. It was also widely adopted in Scandinavian countries (Kaptelinin & Nardi 1997). Norman (2005:14-19) encourages the use of "activity-centered design", and states that there are many historical examples where people have adapted their behaviour to technology, rather than technology being shaped to conform to human needs, e.g. languages and writing systems. People spend many years learning languages and how to write in different writing systems, which are completely artificial and manufactured.

Another example is musical instruments and musical notation, which has remained mostly unchanged for roughly 1000 years (Norman 2015:15). It takes many years to master playing the violin, which requires shaping the arm, elbow, wrist and fingers into uncommon forms, as well as using uncommon muscles for proper posture. Yet people are willing to adapt their bodies to the instrument, as the sound it produces is unique and cannot be produced in any other way. When the activity to be performed is understood (in this case, creating beautiful melodies), the object (the violin) becomes understandable.

Advantages of activity-centered design

Norman (2005) positions activity-centered design as an alternative to human-centered design. He considers human-centered design as an *approach*, as opposed to an underpinning *intention*, as this

thesis does. I suggest that an activity-centered design approach can still be supported by a human-centered design approach. In light of that differentiation, Norman (2005) believes that an activity-centered design approach and a human-centered design approach are similar with the best qualities of human-centered design carrying over. The most notable difference is the attitude and mindset of the designer. Activity-centered design considers the range of actions people may perform, as well as the constraints they may encounter in their environment. This approach also requires a deep understanding of people as well as a deep understanding of the tools, the technology and the reason for the activities (Norman 2005).

Whereas a human-centered design approach focusses on creating a deep understanding of the people who will be using the system or product, an *activity*-centered design approach contends that the more something is tailored to the preferences and skills of a specific target population, the less likely it will be able to be used by anyone else. The contention is therefore that if something is designed to be used by anyone in the world, it is more practical to design it with a deep understanding of the activity to be performed, rather than the people who will be using it. Examples are everyday objects such as teapots (Figure 16 and Figure 17). Teapots have changed very little in shape and usage over hundreds of years, because the *activity* of pouring hot tea stays the same.

Figure 16: Teapot from Dehua, China (produced circa 1644-1700). (The British Museum 2022).

Figure 17: Teapot from Jingdezhen, China (produced 2013). (The British Museum 2022).

Norman (2005:16) states that "[t]o the human-centered design community, the tool should be invisible; it should not get in the way. With activity-centered design, the tool *is* the way" (emphasis added).

Limitations of activity-centered design

In considering only the activity and how best to perform it, the *human* element can easily be overlooked. Amongst other medical issues, repetitive stress fractures are common for violinists and pianists. Norman (2005:15) posits that "neither the instruments nor the notation would pass any human-centered design review". The sound of a violin cannot be produced in any other way however,

but should humans be adapting to objects that could be harmful to them? At which point do the disadvantages outweigh the benefits? Truly understanding an activity to the point of being able to design something fit to purpose around it is also a time-intensive exercise.

Activity-centered design in a South African context

At the time of writing, no scholarly articles relating to activity-centered design in a South African or a healthcare context could be found. However, there are some articles on activity theory available that are not strictly applicable to the context of this thesis.

Activity-centered design in healthcare design

It can be argued that within healthcare there has been considerable activity-centered design that may not be formally documented. One example of this is the stethoscope. The activity of listening to a patient's lungs or heart is standard practice at the beginning of a consultation, and has been for many years. In 1820 René Laennec – a French doctor – created one of the first stethoscopes (from the Greek word for chest, stethos) by using a rolled-up paper to listen to a woman's heart to avoid embarrassment. He later went on to create wooden versions, as can be seen in Figure 18. The well-known binaural stethoscope came to use in the 1840s. (Science Museum 2022).

Figure 18: Laennec's stethoscope. (Science Museum 2022).

Figure 19: 3M™ Littmann® CORE Digital Stethoscope, (3M).

New technological advances have made their way into stethoscopes as can be seen in Figure 19. Digital stethoscopes can be integrated with phones or tablets (the small portable computer variety, not the compressed solid substance that could be a medicine) and allow a doctor to visualise heart beats, as well as detect heart murmurs. However the shape of a binaural stethoscope is almost identical to what

it was 180 years ago, and the activity of a doctor listening to a patient's heart and/or lungs remains unchanged.

Activity-centered design with regard to this thesis

The activities that occur within the radiology workspace are highly specialised, and since I am not a registrar or a radiologist, it would have taken an inordinate amount of time for radiologists to truly explain the activities they perform on a clinical level to me. In a sense this is a good thing for designers. By getting too involved in the technical detail of a problem space (at least initially), it becomes easy to lose sight of looking for holistic, environment-orientated solutions. There are however, certain activities that were investigated and questioned, such as what registrars do when they arrive at work or when they start to report on their cases for the day.

2.4.6 Ethnography

The approach of ethnography is a form of applied social science that draws from various fields such as sociology, anthropology and ethnomethodology (Steen 2011:50). It was pioneered by Lucy Suchman (1987) while working as a researcher at Xerox Palo Alto Research Centre. She observed the way that people used and struggled with the machines and showed films of this to the engineering team. Shortly after, researchers from other labs such as Hewlett Packard, Apple Computers and NYNEX followed suit (Blomberg, Burrell & Guest 2009:72). This field developed as the realisation that designers and developers could no longer only rely on their own experiences and frames of reference in order to create new products, solutions and experiences. Design researchers therefore go "into the field" with the intention of understanding their subjects' day-to-day lives. Design consultancies focussed on this approach were founded in the 1990s, and include IDEO, Fitch and the Doblin group. These companies created an equal partnership between design and research (Blomberg *et al* 2009:72).

For some, ethnography is merely a fashionable term for any kind of qualitative research, while for others, it is less about the method and more about the lens through which people's activities are viewed. Ethnography aims to understand people's current experiences and practices, as well as the way they currently use systems or products. It is founded on four principles: (1) Consider people in their natural settings, (2) Take a holistic view of the problem space, (3) Be descriptive in accounting for the everyday activities happening in the current problem space, and (4) take the subject's view into consideration, i.e. the language they use, how they categorise their space, etc (Blomberg, Burrell & Guest 2002).

The ethnographic approach has a strong affinity and connection to other approaches, such as activity theory and participatory design, amongst others. It differs from participatory design in that its roots are in qualitative social science research, as opposed to being developed as a political and social movement. It shares field-based research methodologies with activity theory and activity-centered design, as well as the notion that behaviour (activity) should be a central focus point. It is more concerned with current "as-is" states and documenting those however (Blomberg *et al* 2002:981).

Advantages of ethnography

An ethnographic approach can help researchers understand the current context in which subjects find themselves, as well as help them gain a holistic view of the problem space.

Limitations of ethnography

A criticism of this approach is that it can easily devolve into being merely a checkbox for design research, falling under the "Implications for design" section in a report (Steen 2011:50). It is important for researchers to fully engage with the rich, complex lives of people to fully gain value from ethnographic investigations (Steen 2011:50).

Ethnographic research carries the risk that accounts can be shaped by the point of view of the researcher, the relationship between the researcher and the subjects, as well as the goals of the project (Blomberg *et al* 2002).

Ethnography in a South African context

Several ethnographic studies have been undertaken in South Africa, many in health-related contexts. Bosire, Norris, Goudge and Mendenhall (2021) undertook an ethnographic study to investigate pathways to care for patients with HIV/AIDS and type two diabetes co-morbidities[29] in Soweto, South Africa.

Through clinical observations and qualitative interviews, Bosire *et al* (2021) established key themes that emerge and hinder the current quality of care that patients receive. Firstly, poor communication. Hospitals and clinics do not communicate effectively with one another, which may result in patients not receiving optimal care. This leads to the next theme namely, patient information not being centralised. Because healthcare practitioners can only treat what they are aware of, they may not

[29] Co-morbidities mean that a patient has more than one condition simultaneously, thus increasing the complexity of their care.

always be aware of co-morbidities patients have, or other medications they are currently taking. For example, Bosire *et al* (2021) witnessed numerous patients bringing unused medications to appointments – there was even a drawer at the clinic where these were kept – at which point nurses would berate patients for not adhering to their treatment. In reality they had been prescribed medications by different doctors for the same condition, thus receiving double dosages.

Other observations from the ethnographic study included staff shortages, unavailability of doctors, lack of resources such as medications, the proximity of clinics being problematic, and interprofessional conflicts between healthcare professionals. This last point was highlighted as a reason for why collaborative care was difficult.

Ethnography in healthcare design

Blomberg *et al* (2002) conducted an ethnographic study for a healthcare provider that wanted to build a web-based portal that would facilitate communication between employees, employers and clinicians, and most importantly improve employee health. Research was conducted in employees' homes, health clinics and employer offices. It also involved interviews, as well as shadowing patients as they interacted with healthcare practitioners at clinics.

One of the main findings the project exposed was that the healthcare experience consists of several stages, and different activities are associated with each step. Awareness and/or acceptance of a condition is the first stage, whereafter people express a desire to search for relevant information. As knowledge grows, the patient eventually begins to take more direct action. At this point the key is then to maintain this behaviour for the appropriate amount of time (often indefinitely) depending on the diagnosis. Once the behaviour commences, positive reinforcement is crucial and people respond well to quantifiable measures of progress, such as cholesterol or T-cell counts.

The team therefore recommended a system that allows patients to monitor and log relevant information related to their healthcare. It was also found that communication between healthcare workers and patients is crucial, but often impeded by a variety of factors. By combining these insights, the team recommended building a health history tool that allowed patients to monitor and log relevant information about their health. Healthcare workers would also be able to view the information, which meant communication improved and patients were empowered to take ownership of their own health.

Ethnography with regard to this thesis

An ethnographic approach was partly taken for this thesis, as it aimed to determine registrars' current working environment at Universitas Academic Hospital. While observation was not possible due to Covid-19 restrictions, care was taken to understand registrars' day-to-day lives through in-depth interviews. It also formed the lens through which people's activities were viewed.

2.4.7 Lead user approach

Von Hippel (1986) pioneers this approach by suggesting that many new solutions are created and conceptualised by innovative users, not designers or researchers. By identifying these individuals, researchers can benefit from their insights. "Lead users" can be identified by two characteristics: (1) those who are experiencing needs that will likely be general in a marketplace months or years before the rest of the market – ideally experts in this field, and (2) those who stand to benefit greatly from solutions to those needs (Von Hippel 1988:107). The more dissatisfied a user is with the current offering and the more they stand to benefit from a novel solution, the more they will be motivated to be a "lead user" involved in new product development. Selecting lead users for a project is not a formulaic process, it is instead a creative one that needs to be tailored to the requirement each project requires (Luthje & Herstatt 2004).

Following this approach takes the form of four steps:
1. Identify an important market or trend
2. Identify lead users regarding the trend
3. Analyse data from lead users
4. Test the data on ordinary users. (Von Hippel 1988:108)

What makes this approach different from participatory or co-design approaches is the particular screening criteria for participants. Generally, they are considered experts in their field. This approach is primarily oriented towards businesses or commercial development and was originally proposed as a way to identify commercially attractive novel developments by users (Franke, Von Hippel & Schreier 2006:303). It can be used in conjunction with a participatory or co-design approach and can be lead-user-driven within those contexts.

Examples of lead user involvement can be found in open source development, crowdsourcing, and user-generated content (Steen 2011:51). A particularly significant application of this approach can be observed in the development of specialised equipment in sports such as kite-surfing, mountain biking and snowboarding (Franke *et al* 2006; Shah 2000; Tietz *et al* 2004). It has been shown that leading-

edge sporting enthusiasts are able to discover issues with existing equipment only because of continuous and skilful practise of the sport (Luthje & Herstatt 2004). Lead users are usually happy to participate in research free of charge for one of two reasons. Firstly, if they are in non-competing industries, there is no conflict of interest in sharing information. And secondly, lead users tend to innovate because they need to, not because they are looking for some form of competitive advantage. Therefore, they are happy to transfer their ideas to a willing supplier or manufacturer that can assist in bringing them to life (Von Hippel, Thomke & Sonnack 1999:8).

Advantages of a lead user approach

Traditional market research aims to incorporate groups of 'typical' people who represent their target audience. However, the problem is that people are "steeped in the familiar". In other words, they are constrained by their lived experiences and frames of reference and will usually find it difficult to generate novel product concepts that cause friction with the familiar. They will also simplify complex systems they are already familiar with (Lüthje & Herstatt 2004:554; Von Hippel 1986; 1988). This is called "functional fixedness" (Franke *et al* 2006:302). This term simply means that those who use an object in a specific manner may find it difficult to think of novel ways to use it (Franke *et al* 2006:302). Lead users alleviate this problem because they do not need to imagine themselves in a new, not-yet-existing situation. They are already living at this forefront and their first-hand experience can thus directly influence the development of new, innovative products, or novel uses of existing products (Luthje & Herstatt 2004: 557).

Limitations of a lead user approach

There is a risk that the lead users identified may not actually be representative of the wider market. It has been shown that "early adopters" of technologies and novel solutions differ in significant ways from the majority of the users that follow them (Von Hippel 1988). There is a risk that lead users drawing from a bank of unique information, i.e. their personal experience as well as what relates to their skill level, may not be truly representative, or their experience not applicable to all users in a particular market and thus will not appeal to general customers (Luthje & Herstatt 2004:560).

Studies have found that the ideas generated by a lead user approach have much higher commercial attractiveness (Franke *et al* 2006:303), and these lead users often dominate the development of innovations with mass market appeal (Luthje & Herstatt 2004:556). Even with that knowledge, it is difficult to know whether a lead user approach will indeed result in better outcomes, as opposed to holding a workshop where participants can give input, such as in participatory or co-design

approaches (Luthje & Herstatt 2004:565). There are several studies that demonstrate that interactive groups do not outperform non-sharing groups (Fern 1982; McGlynn *et al* 2004).

Finding true lead users is rare (Von Hippel *et al* 1999:5). And, because lead users are difficult to identify,[30] it is possible that a project may involve "regular" users unbeknownst to the organisers, depending on how the identification and selection are conducted. The tactic for recruiting lead users is twofold: a "screening approach" that involves screening a large number of participants to determine if they have previously been deemed as lead users, and a "networking approach" where a small number of people are asked to refer the researchers to others in their field that may have new needs, or that have been actively working on their own solutions (Luthje & Herstatt 2004:563-564). This eventually leads one higher up the "pyramid of expertise." As can be seen in Figure 20, this networking occurs not only within the specific field that researchers are looking to investigate – in this case, medical radiology – but also in related fields that could possibly benefit from similar innovations (Von Hippel *et al* 1999). Both approaches to finding lead users are time-intensive for the researcher/s.

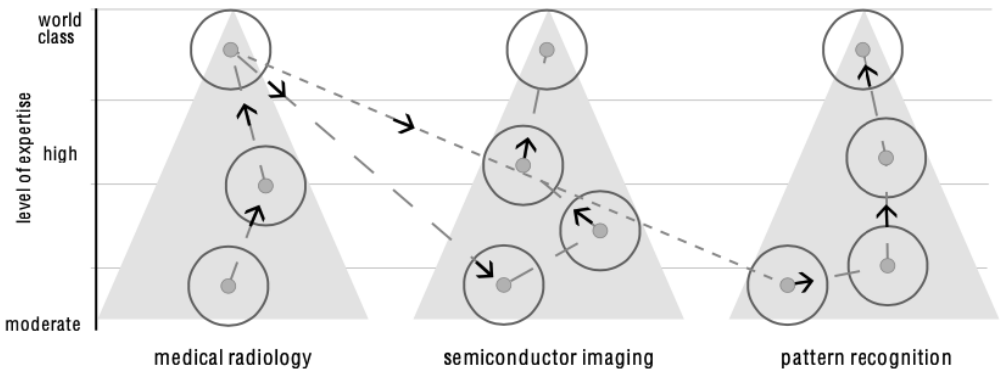

Figure 20: Networking to lead users at the top of the "pyramid of expertise". (Von Hippel *et al* 1999).

Since lead users are experiencing the needs of a specific market months or years ahead of the rest of the market, there is a chance that by the time the general market catches up, that particular need or issue may no longer be relevant (Von Hippel 1988:114). One example of this is innovations in cassette tape technology; once CDs were released, this was no longer relevant.

Finally, bringing together a group of people for any form of workshop also involves a considerable investment of time and money. Human and financial resources are implicated (Luthje & Herstatt 2004:565). A high level of commitment is required from the team members and senior management to ensure the project is carried out thoroughly (Von Hippel *et al* 1999).

There is also a divergence of interests between lead users and the clients or manufacturers they are working with. Lead users want to get exactly what they need within the financial constraints they may

[30] As mentioned earlier, selecting lead users is not a formulaic process and requires a creative, tailored approach.

have. On the other hand, clients or manufacturers want to lower development costs by using solution elements they already have and making commercially viable solutions. Some innovations may be considered too costly or too specific to the individual to be commercially viable (Von Hippel 2005:68). This may lead to lead user frustration as they were brought in as an expert, but their needs are not being met.

Lead user approach in a South African context

The Health Information Systems Project discussed under participatory design (page 33) actually started with a lead user innovation. In 1988 the manager of the paediatric department (6 wards, 250 beds and an outpatient facility) at Cecila Makiwane Hospital in the Ciskei began to develop a digital information system for the department (Braa 1996). Their objectives were twofold, namely to improve the communication between the hospital and the communities they served, and to make information more freely available within the hospital. The core of the system was a patient record database that included diagnosis and treatment history. The manager, who was a computer enthusiast and programmer, developed the first prototype himself in Clipper, a programming language that operated under MS-DOS. The system underwent various changes in the 9 months following implementation, including being made more user-friendly, and allowing it to run properly. The manager/developer left after this time, and for 8 years the system stayed virtually unchanged until the Systemarbeid team were able to resolve ongoing issues and make it more robust. The lead user, the original manager/developer, innovated beyond what was commercially available at the time, and incorporated feedback from other users, i.e. doctors. He was therefore able to create a system that catered for their unique needs.

Lead user approach in healthcare design

Although the previous example occurred in the context of healthcare design, it was not documented specifically in terms of a lead user approach. The following case study is, and allows us greater insight into how this approach can be used in healthcare design. In September 1996 a product development team at 3M, an international company with an interest in innovation in various industries, was charged with creating a breakthrough in the field of surgical drapes, an adhesive material that prevented infections from spreading during surgery. Initially the team's goal was to "find a better type of disposable surgical draping" (Von Hippel *et al* 1999:7). Von Hippel, Thomke and Sonnack (1999) write that this goal evolved over time as lead users were incorporated. They started by researching the trends in infection control as they would be unable to determine what the leading edge in this field was without first having that knowledge themselves. They discovered that most research was aimed at

trends in developed countries, and very little was available regarding infection control in developing countries.

The team then went to hospitals in Malaysia, Korea, India and Indonesia, and discovered that because solutions for infection control were very costly, doctors were instead forgoing prevention and prescribing cheap antibiotics after surgery. This led to great concern, as drug-resistant bacteria was becoming more of a concern worldwide (Von Hippel *et al* 1999). As a result, the goal of the project was redefined as finding cheaper and more effective ways to prevent infections from spreading or starting without reliance on antibiotics, or possibly even surgical drapes.

Considering the fields that might afford the inspiration they needed, veterinary science was included, as veterinarians were able to keep infection rates very low, despite having patients who are "covered with hair, … don't bathe, and … don't have medical insurance, so the infection controls that … [are used] can't cost much" (Von Hippel *et al* 1999:8). Make-up artists in Hollywood were also consulted as they are experts in applying materials that do not irritate the skin and can be easily removed when no longer needed.

The final version of the team's goal was formulated as, "find a revolutionary, low-cost approach to infection control". The workshops the team held ended with six new product lines, as well as a radical new approach to infection control (Von Hippel *et al* 1999:8). The team recommended a move away from products that are "one size fits all" (every patient received the same surgical drapes, regardless of their circumstances), and rather focussed on individualised care. Some patients, such as those with diabetes or suffering from malnutrition, were at higher risk of infection after surgery. By adopting this approach, patients could be treated before surgery in order to reduce their risk of infection in the first place (Von Hippel *et al* 1999:8-9).

Lead user approach with regard to this thesis

A lead user approach was employed for this study, but not in full as the subject pool was already quite small. The list of available doctors to contact included eight registrars and two radiologists who had very recently qualified for the registrar programme at Universitas Academic Hospital. Of those, six registrars participated in interviews, as well as one recently qualified radiologist. Although registrars are not-yet-qualified radiologists and in effect, students, they can be considered authorities in their own working environments. Information regarding the working environment was thus obtained from authorities functioning in it, and information regarding other possible radiology working environments was obtained from qualified radiologists working in private practice. However, these

lead users were not intensively involved in creating solutions for their situation, as the time required for this was deemed prohibitive.

2.4.8 Contextual design

This approach, defined by Beyer and Holtzblatt (1996; 1998; 1999), draws on ethnographic research and participatory design in order to be a "backbone for organising a customer-centred design process". It aims to assist with collecting requirements for creating new systems directly from those involved, by observing people in their natural, often work-related, contexts, (Steen 2011:51). Within the software development industry this approach has evolved to be a research method in itself known as "contextual inquiry" (Holtzblatt & Jones 1993).

The core principle of contextual inquiry is straightforward, namely, "go where the customer works, observe the customer as he or she works, and talk to the customer about the work" (Beyer & Holtzblatt 1998). The researcher takes on a kind of "apprentice role" where they learn everything they can about a role from the "master" (Beyer & Holtzblatt 1998:42-46). Beyer and Holtzblatt (1999:33) create a process for contextual design with seven steps, which is very reminiscent of the design thinking processes discussed in Chapter Three.

Advantages of contextual design

Beyer and Holtzblatt (1998:41) maintain that design processes work best when built on natural human behaviour. It is easier for people to act out their daily routines than trying to think about them, remember steps, and talk about them. People also are not always aware of everything they do, because these things have become second-nature to them. By seeing people work in their natural environments, we can observe what really matters to them. Other advantages of contextual inquiry are that it (1) reveals motivations and details implicit in people's work, (2) makes people and their work needs real to the researchers, (3) uses data as the basis for making decisions, and (4) creates a shared understanding among the team.

Limitations of contextual design

Using the kind of "apprentice" model (Beyer & Holtzblatt 1998) where the subject discusses their work and takes the researcher through it is time-intensive, and requires a lot of effort and patience from the subject. The subject may not be a good 'teacher', i.e. not know how to convey their inherent knowledge, which may make them uncomfortable and frustrated. There is also a risk that subjects may adapt or change the way they work because they are being observed. People may also feel

uncomfortable to be watched whilst working. They may feel that the researchers may be judging them for performing tasks 'correctly' or 'incorrectly'. This feeling of judgement and getting things right is an ongoing likelihood with any form of usability testing or subject participation.

Contextual design in a South African context

In order to understand the ways of working and current frustrations among Java mobile application developers, Samuel (2009) conducted a contextual inquiry with 64 expert mobile application developers at their place of work: the Computer Science department laboratory at the University of Cape Town. The intention of the inquiry is to better understand the programming difficulties faced while using one Integrated Development Environment (IDE) or another. After watching the programmers and interviewing them, Samuel (2009) formulated hypotheses and showed them to the programmers to get their feedback. This allowed participants to correct any misconceptions and clarify their intentions with specific tasks. After analysing the results, Samuel (2009) focused on how to better support mobile application developers who are developing mobile applications for a wide variety of mobile device platforms. The end result of the project was the creation of a plugin that can be incorporated into the IDE that the programmers used and allowed them to open the application on various mobile devices without the need to adapt the application for each device.

Contextual design in healthcare design

Surma-aho, Hölttä-Ottoa, Nelskylä and Lindfors (2021) conducted research into creating guidelines for medical device design. As part of this study they spent 64 hours in a gynaecological operating unit to observe how devices were used during surgery, as well as conducting interviews with staff. The importance of usability is especially pronounced in operating rooms, where unnecessary complexities may result in human error and catastrophic results. Their contextual inquiry focussed on informal discussions during healthcare practitioners' work, as well as inconveniences and nuisances they experienced during operations. Figure 21 shows an observational diagram of how an operating room is generally laid out during a laparoscopic operation.

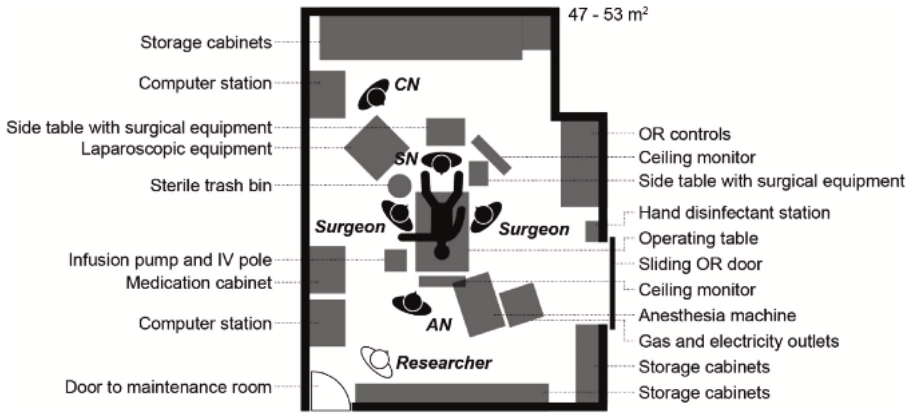

Figure 21: The observed configuration of an operating room during laparoscopic surgery. (Surma-aho *et al* 2021).

Because of this in-depth investigation, they were able to make recommendations regarding the usability requirements of existing equipment, as well as analyse how environments can be improved. There were implications both for better device design, as well as better device procurement.

Contextual design with regard to this thesis

Since contextual design can provide valuable insights that people may not even realise are important in their environments, a contextual inquiry was initially included as part of the research methodology. However, due to the ongoing Covid-19 pandemic, I was not able to obtain access to Universitas Academic Hospital. As part of my ethics application to the University of the Free State I was asked whether it was possible to conduct my research remotely, in the form of interviews. This approach was thus abandoned in favour of interviews with registrars about their environments instead. Thus, true contextual design was not able to be implemented, but any thoughts around the registrars' context were instead inferred or understood from interviews. Conducting interviews alone does not constitute human-centered design, but it starts us along the path towards it.

Constructing hypotheses to be fed back to the research participants as per Samuel (2009) was also included in the research proposal of this thesis, but also had to be abandoned, due to time constraints, and availability constraints of registrars, as has been mentioned previously.

2.4.9 Empathic design approach

Empathic design aims to design by understanding people's feelings towards a system or process. It aims to empathise with people's lives and their work, experiences and emotions. Its roots are in design practice, rather than design theory (Mattelmäki, Vaajakallio & Koskinen 2014:67). There are different versions of empathic design, for instance, Leonard and Rayport (1997) suggest that *observation* should

be the basis, conducted in the consumer's own environment, as opposed to other more traditional contexts such as usability laboratories or focus groups. Koskinen, Mattelmäki and Battarbee (2003:47) describe empathic design as "empirical research techniques that provide designers access to how users experience their material surroundings and the people in it, including themselves as key characters of their everyday lives". It requires designers to immerse themselves in roles as well as keep their imaginations in check with empirical data. Considering traditional research is not enough; empathic design requires creative interactions between members of an interdisciplinary team.

Observing people leads to identifying unarticulated needs – needs that the person may not even realise they have, but would improve the way they use a product or service. This allows companies to 'delight' their customer by pushing beyond what they anticipated and providing something they did not even realise they needed.

Empathic design is built on a history of human-centered design, but its origins as grounds for design are more recent, going back to the writings of Leonard and Rayport (1997) in marketing, Sanders and Dandavate (1999) around design tools, and Dandavate, Sanders & Stuart (1996) in product development.

This idea of observation may sound similar to contextual design, and the approach may even sound closely related to activity-centered design, participatory design, and ethnography. Empathic design is part of the movement towards context-sensitive design, but it does not share the theoretical background or politics of participatory design or activity-centered design. The links to participatory design are much more recent. This was inspired in part by cultural probes (discussed later in this chapter), although empathic designers consider them more as inspirational rather than situational (Mattelmäki *et al* 2014:68). Empathic design differs from ethnography as it focusses on what *could be* by testing ideas and prototypes, whereas ethnography generally seeks to investigate what currently *is* without intervening (Steen 2011:53). It focusses on individual desires, emotions and moods in activities, using those experiences and emotions for inspiration (Mattelmäki *et al* 2014).

In 2013 Tuuli Mattelmäki, Kirsikka Vaajakallio, and Ilpo Koskinen wrote an article *What Happened to Empathic Design?* This was a question this author had started to ask, as most articles about this approach were published in the late 1990s or early 2000s. Mattelmäki *et al* (2013) maintain that it is alive and well in Finland, but that it is now more in the background than other approaches. This is certainly the case with Mattelmäki, a seminal researcher and writer on empathic design, who has written mainly about co-creation, co-design, and service design since 2013. The concept of empathy is vital to human-centered design, as can be seen in the design thinking processes in Chapter Three. Most start with the first step of *empathising* with the people who are being designed for.

Leonard and Rayport (1997:108-113) define a five-step process for the empathic design approach: (1) Observation, (2) Capturing Data, (3) Reflection and Analysis, (4) Brainstorming for solutions, and finally (5) Developing prototypes of possible solutions. When compared with the various practical processes for approaching design problems mentioned in Chapter Three, they exhibit many similarities. These other processes make use of steps such as:
(1) Empathise/Discover/Understand/Observe
(2) Define/Reflect/Specify requirements
(3) Ideation/Sketch/Make/Develop
(4) Prototype, and
(5) Test/Validate/Implement/Produce designs

Comparisons of different practical processes for approaching design problem spaces as discussed in this thesis can be found in Table 2 on page 99. Empathic design already suggests a practical method to approaching design problems, which is reflected in the more recent processes. This again hints to empathic design being an 'early' version of human-centered design, and an approach that forms part of its basis.

Advantages of empathic design

At the heart of empathic design is the idea of "role immersion". This is the idea that the closer the designer comes to the real user, the more they can step into their world and live and experience their emotions in order to transform constraints and ideas into appropriate design solutions (Mattelmäki *et al* 2014).

Limitations of empathic design

Empathic designers run the risk of falling into what is called the "empathy trap", where the designer's attempts to be empathetic might end up defining popular reflections, instead of producing more innovative, radical futures (Mattelmäki *et al* 2014). Another risk is that ideas that arise from an empathic design approach may be criticised for not complying with what people have asked for. According to Leonard and Rayport (1997:113) this is exactly the point. People can only ask for what they can imagine, and by truly understanding their needs, they can be answered in a way they never expected. However, it does run the risk of not being successful.

Empathic design in a South African context

The empathic design approach has not been utilised in a South African context as yet – at least not in a pure sense. Various projects that utilise empathic design as it informs co-design, participatory design and contextual design have been undertaken, as discussed under those topics. An example of empathic design as utilised in Namibia is discussed as part of the below project, which started out in the district of Rio de Janeiro, Brazil.

Empathic design in healthcare design

Judice (2014) undertook an empathic and participatory design approach to design for health agents in Vila Rosário, Brazil. The main goal of the project was to convey healthcare information to the community in order to help them become self-sustainable. The health agents they worked with were themselves members of the community who had received some medical training to enable them to recognise the symptoms of tuberculosis (which was a major problem in the area) and were able to guide people to treatment. Empathic design methods were deemed important for this study as it was conducted in an impoverished community where many were too shy to speak about the reality in which they lived with regards sanitation, hygiene, drugs, alcohol, healthcare, etc. It was vital to understand these topics in order to help the community in a meaningful way through design.

Judice conducted in-depth empathy probes, which allowed the health agents to understand their subjects in much greater detail. This was combined with ethnographic research, as well as participatory design which included the health agents. Judice (2014) used the insights from the research approaches and methods to focus on creating visual communication for the community. This included a logo that was utilised on a uniform for the health agents, along with illustrated posters that communicate the path to treating tuberculosis (Figure 22).

Figure 22: Illustrations depicting the treatment for tuberculosis, along with the logo for the Vila Rosário institute. (Judice 2014).

After concluding the Vila Rosário project, Judice sought to understand whether the methods and designs they had used in that community were transferable to another context. By happenstance they had the opportunity to investigate this in a marginalised community in Windhoek, Namibia.

They found that the overarching design approach worked, although there were parts of the design managing that needed to be localised to foster a sense of ownership and pride amongst the community. The idea of a "health agent" was different as well; in Brazil they were local community members, whereas in Namibia people associated the words with doctors and nurses, i.e. members of a medical institution.

Empathic design with regard to this thesis

A concerted effort was made to empathise with the registrars through informal, semi-structured interviews. The open-ended discussions allowed me to understand their needs, frustrations, daily working environments, and what they as people valued. One of the questions asked was what registrars did first upon arriving at the hospital and their department. One registrar mentioned losing their father at the beginning of the Covid-19 pandemic and for this reason, every morning before they went into work, spent 10 minutes in their car listening to gospel music in order to prepare mentally for the day and get into a good mindset for the sake of their colleagues. That empathy and desire to see doctors as people and not just clinicians, forms the very basis of this thesis and why it was attempted in the first place. The empathic design approach was thus a strong influence on this thesis and the approach that was utilised.

2.4.10 Emergent design approaches

While all of the above design approaches have been discussed in depth amongst academia, there are two relatively new approaches that are not yet firmly established, but are worth mentioning due to the ways of thinking they encourage.

Circular design

The first is that of "circular design". IDEO.org (2015) is the non-profit branch of an internationally-renowned design agency that aims to inspire change. IDEO.org partnered with the Ellen MacArthur Foundation to work on a paradigm they coined as "circular design", which is the idea that design should not just focus on a solution, but should be a cyclical process that constantly re-evaluates the changing landscape it finds itself in (The Circular Design Guide 2018). This concept ties in closely with the life-centered design, as discussed below.

Life-centered design

John Thackara (2020), bioregional designer and visiting professor at Tongji University in China, proposes that design systems should consider not only the people who use them, but also the environment, sustainability, and lifestyles - design does not happen independently of these systems. He states that, "we must learn to think of the places where we live as ecosystems, not as machines."

Thackara's design approach is listed as one of Fjord's[31] Trends of 2020 (Curtis & Cotton 2020), which terms it as "life-centered design". He critiques human-centered design for separating people from their ecosystems, and emphasises that people need to be considered as part of a bigger ecosystem, as opposed to being at the centre of design. This ties into an earlier critique of human-centered design that it can easily become anthropocentric, and disregard how it affects other aspects of our planet.

It is unclear how Thackera proposes to implement the idea of life-centered design while still creating products that are intended for primary use by humans. If this is merely a call for human-centered design to be reformed to also consider the environment, then it would be more suitable as a philosophy, rather than as an approach.

2.4.11 An overview of human-centered design approaches

Now that all of the human-centered design approaches have been discussed, it is possible to note in shorthand the advantages and limitations of utilising the different approaches, along with the seminal authors that discuss them.[32]

Table 1: Comparison of the different human-centered design approaches

Approach	Advantages	Limitations	Authors
Participatory design	• Includes and empowers people • Creates shared experiences • Creates a sense of ownership • Encourages participation, • Allows for a bottom-up approach	• Time-intensive • Solutions may not be appropriate • Requires expert designers to guide the process • People can only create what they can imagine	Braa 1997, Ehn 2017, Greenbaum & Kyng 1991, Norman & Spencer 2020, Schuler & Namioka 1993, Steen 2008, 2011, Törpel 2005

[31] Fjord, part of Accenture Interactive, is an international design and interaction consultancy. Their yearly design trends are widely anticipated and considered a benchmark for upcoming business and design trends.
[32] Many of the approaches as seen here are similar, with only philosophical or semantic differences in origin, and not true differences in approach. This points to the fact that no true 'single' approach is really possible. Given that every project has different needs, pluralism is necessary. Designers and clients also have different preferences. This overview is helpful to spot potential blind spots for approaches.

Co-design	• Includes and empowers people • Creates a sense of ownership • Long-term: less reliance on specialised designers • Concerned with future states and experiences	• Requires creative initiative from the entire team • Power and hierarchy has to be relinquished • Designers are required to take on a facilitator role • Onus is on designers to put forward the best generative materials • Designers can introduce bias	Sanders & Dandavate 1999, Sanders 2000, Sanders 2006, Sanders & Steen 2008
Community-based design	• Includes and empowers people	• Time-intensive • Solutions may not be appropriate • Requires expert designers to guide the process • Solutions may not address underlying issues	Norman & Spencer 2019, Norman 2020
User-centered design	• Leads to the development of products that are more effective, efficient and safe • Including end-users ensures solutions are fit for purpose • Helps designers manage expectations around a new product • Creates a sense of ownership • Multidisciplinary teams can cover various aspects: psychological, sociological, anthropological	• Can be costly • Time-intensive: takes time to gather data and understand environment • Resource-intensive: financial and human • Multidisciplinary teams need to learn to communicate effectively among themselves • MVPs are exploitative towards users	Abras *et al* 2004, Keinonen 2010, Norman 2013, Preece *et al* 1994 & 2002, Steen 2011
Activity-centered design	• A deep understanding is gained of the tools, the technology used, and the reason for the activities • More universal designs	• Activities have to be understood in-depth • Time-intensive • Solutions may be harmful to people	Norman 2005
Ethnography	• Holistic view of the problem space	• Risk of only being a 'checkbox' for design research • Researcher can alter accounts • Researcher may be biased	Blomberg *et al* 2002, 2009, Suchman 1987
Lead user approach	• Innovative, cutting-edge solutions • Custom solutions • High likelihood of solutions having mass appeal	• Lead users are difficult and time-intensive to identify • High costs involved with creating custom solutions • Time-intensive involvement for lead users • Novel concepts may be difficult to create when	Franke *et al* 2006, Luthje & Herstatt 2004, Von Hippel 1986, 1988, 2005, Von Hippel *et al* 1999

		steeped in the present • Inadequately skilled teams can derail a project • Requires support from the instigator of the research (corporate or business partners)	
Contextual design	• Builds on natural human behaviour • Reveals motivations and details implicit in people's work • Makes people and their work needs real to the researchers • Uses data as the basis for making decisions • Creates a shared understanding among the team	• Time-intensive • People may feel judged • Participants may not be the best teachers • Changed way of working due to being watched • Requires physically being on-site	Beyer & Holtzblatt 1996, 1998, 1999, Holtzblatt & Jones 1993
Empathic design	• Role immersion allows development of empathy • Allows designers to create for possible futures, not just existing needs	• Risk of falling into the "empathy trap" • Requires creative interactions between members of an interdisciplinary team. • By answering a question nobody asked, it will either be successful or fail	Leonard & Rayport 1997, Koskinen *et al* 2003, Mattelmäki *et al* 2014

2.5 Conclusion

This chapter has investigated the background of how human-centered design became a prominent design philosophy. It has explained the broader philosophy of human-centered design especially with regard to how it developed, which was the initial objective. This tied into the bigger aim which is establishing how human-centered design can be used in a South African context. Different human-centered design approaches have been investigated in both South African as well as healthcare contexts, and their advantages and limitations critiqued. This has set the stage for examining how these approaches can be implemented practically.

CHAPTER THREE

PROBLEM SPACES, DESIGN THINKING, AND DESIGN PROCESSES

At this point the different design problem solving processes can be set aside to present and create a human-centered model that synthesises and builds on accepted standard practices. The intention is to create a model that works within a South African context. My second aim is to develop a framework underpinned by human-centered design for a South African context, in particular that of radiology in public hospitals. The first objective is to explore and compare existing frameworks, and the second is to craft a framework for this particular problem space. In order to understand problem spaces, we first look at design problems themselves, and why specifically articulated 'design problems' are much less common than one may think.

The goal of design is to solve problems, improve situations, meet needs, or create something useful or new (Friedman 2003:508). According to Herbert Simon[33] (1970:112) design is the method of "[devising] courses of action aimed at changing existing situations into preferred ones". This chapter examines what makes design problems unique and difficult to solve, as well as why the process is not straightforward. It also looks at existing practical processes for tackling design problems, and establishes a new framework that is used in Chapter Four to conduct a case study.

3.1 Investigating design problems

The physicist Albert Einstein said that "[t]he formulation of a problem is far more important than its solution which may be merely a matter of mathematical or experimental skill. To raise new questions, to look at old problems from a new angle marks the real advances in science." Or in our case: advances in design. This statement is applicable to various fields, including that of design. Simon (1973:187) states that, "there is merit to the claim that much problem solving effort is directed at structuring problems, and only a fraction of it at solving problems once they are structured."

Dorst (2003:1) posits that design methodology has traditionally been focussed mostly on the *process* of designing, and less so on the activities needed to support these design activities. This is depicted in Figure 23. This diagram indicates a vast oversimplification with regard to how design processes typically work, and how people actually engage with design. This "oversimplification" of the processes

[33] Herbert Simon was an American economist, Nobel Prize laureate, cognitive psychologist, and early pioneer of artificial intelligence research.

and steps in the design process is a theme that can be seen in every design process discussed in this chapter. Thoughts on the reasons for it are discussed later, on page 100.

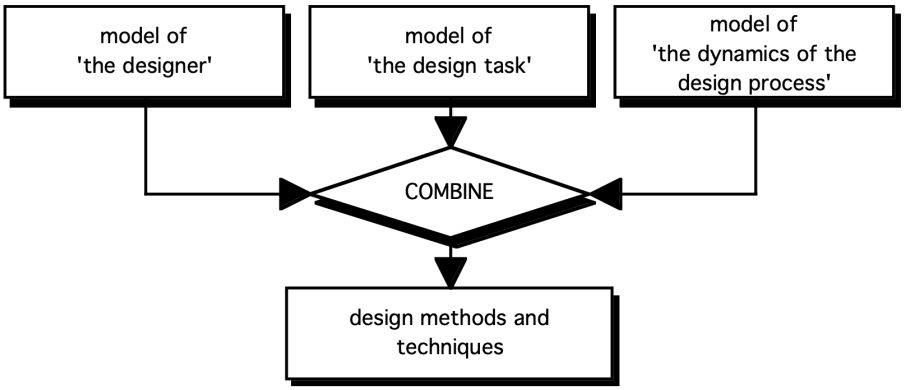

Figure 23: The three dimensions of design activities. (Dorst 2003).

As important as it is to find solutions to problems, it is arguably more important to first define what the actual problem is that is to be solved. Without ensuring that the right problem is being addressed, it is possible that symptoms are addressed instead.

But what causes these design problems in the first place? Friedman (2003:509) states that there are many reasons for design failure, including lack of resolve, method or ability. Designers can also fail because of the context of their project or client, failure to understand the design process, and lack of proper training. Considering design problems specifically, there are various aspects that make them difficult to engage with.

3.1.1 Well-structured and ill-structured problems

Design problems tend to be complex, as there is rarely a specific or univocal ‘definition’ and ‘solution’. Design thinking and decision-making do not adhere to a strictly linear process, and also do not fit into the traditional thought pattern of the design process being divided into two phases, namely problem definition and problem solution (Buchanan 1992).

Design is also not a linear process; it does not have a specific ‘beginning’ or ‘end’. It has traditionally been convoluted as, unlike with scientific experiments, parameters are often not well-defined, and can change quickly when people are involved. Paton and Dorst (2010) note that designers report a need to get to “the problem behind the problem”, which allows them to create a fresh perspective.

Simon (1973), differentiates between what he deems “well-structured” and “ill-structured problems”. This discussion is situated in the context of artificial intelligence training models, but has been applied

to many other fields involving complicated problems needing to be defined before they can be approached, as is the case with design.

It's difficult to formally define exactly what a well-structured problem is, although Simon (1973:183) provides the following list of characteristics, which is not exhaustive:

1. There is a definite criterion for testing any proposed solution, and a mechanisable process for applying the criterion.
2. There is at least one problem space in which can be represented [by] the initial problem state, the goal state, and all other states that may be reached, or considered, in the course of attempting a solution of the problem.
3. Attainable state changes (legal moves) can be represented in a problem space, as transitions from given states to the states directly attainable from them. But considerable moves, whether legal or not, can also be represented—that is, all transitions from one considerable state to another.
4. Any knowledge that the problem solver can acquire about the problem can be represented in one or more problem spaces.
5. If the actual problem involves acting upon the external world, then the definition of state changes and of the effects upon the state of applying any operator reflect with complete accuracy in one or more problem spaces the laws (laws of nature) that govern the external world.
6. All of these conditions hold in the strong sense that the basic processes postulated require only practicable amounts of computation, and the information postulated is effectively available to the processes—i.e., available with the help of only practicable amounts of search.

Well-structured problems that adhere to all of these criteria are not found in the real world (Dorst 2006:7), but are instead, structured for artificial intelligence decision-making models to measure success against. It is supposed that by making aspects of ill-structured problems well-structured, it allows for it to be solved to some extent.

Simon puts this into context by giving the example of an architect commissioned to design a new house, and thus structuring the problem into a well-defined one. The starting point for defining a problem is firstly considering the constraints of the space (Reitman 1965:169):

> One of the interesting features of many of the problem instances… is that even though they generally would be considered complex, they include very few constraints as given. Composing a fugue is a good example. Here the main initial constraint, and it is an open constraint at that [i.e.. one that is incompletely specified], is that the end product be a fugue. All other constraints are in sense supplementary, generated from one transformation of the problem to the next.

When applying this same structure to the problem space at hand, for instance a radiology workspace in a public hospital, the immediate hard limitations that come to mind are budget, manpower and inter-departmental structures. Budget, because this is controlled on a government level and not an easy task to motivate for, and manpower, exactly because of budget. You can't hire more people without the funds necessary for remunerating them. This thesis specifically investigates the radiology department, but there are issues and concerns that span various departments that may not be open to change. Even within the radiology department, because they did not request this study, there may be resistance or hesitancy to implement change. This will need to be investigated. The basic needs of a

radiology department have been taken into consideration, and additional requirements have been obtained through conversations with the radiologists. In the end, this project required the design of goals that are incompletely specified. The more experienced the problem-solver (or designer), the less the client would be expected to provide the constraints, as they define them themselves.

3.1.2 The designer/problem-solver as agent of change

This starts to hint at the fact that the ill-structuredness of a problem may not be a characteristic of the problem itself, but rather linked to the capabilities of the problem solver (Dorst 2006:6). The person involved in problem solving actually influences the nature of the problem. The problem may be changed simply by being observed and investigated. It is therefore imperative to not only have a description of the problem and the design, but also of the problem solver, whose interpretation of the problem sets the tone going forward. This interpretation takes centre stage once it becomes clear that design consists of multiple steps, and not a once-off decision. Furthermore, this interpretation becomes more layered with each step of the design process, and subjective decision-making by the problem solver becomes a major influence on the overall solution being worked towards (Dorst 2006:9).

Inasmuch as individual decision-making can be a *subjective* process, *objective* interpretation can also be considered in the design process, which is ultimately decided by the designer working on the problem.[34] Deciding to include an *objective* process is *subjective*. The decision-making process needs to be controlled and it must be able to justify decisions to stakeholders of the project. In such a case, goals and objectives of the project can be used to discuss *subjective* decisions. By discussing the methods used between designer and stakeholder, the process becomes more objective as it consists of compromise and outside influence. Stakeholders are also vitally important in the design process, as they serve to determine whether a solution *is* actually a solution. This can be judged on a sliding scale of better or worse depending on whether it meet the requirements and goals of the stakeholders set out at the beginning (Dorst 2006:15, 2015:43). Subjective interpretation becomes important when a problem is ill-structured, as it allows for more freedom of interpretation (Dorst 2003:6).

Levels of design expertise

Another factor to consider is the level of expertise of the problem-solver. Dorst (2003:9, 2015:57-58) presents a framework of seven "levels" of design expertise.[35] Firstly there is the *naive* problem-solver, who is merely focussed on results. This stage is performed by people every day in general

[34] Ultimately, it is nearly impossible to strictly differentiate between the subjective and the objective.
[35] These levels are based on earlier work crafted specifically for the context of design by Dorst (2003) and Lawson and Dorst (2009). This is in turn based on Dreyfus' (2002) five levels of general "skill acquisition" which is grounded in phenomenology.

circumstances. It involves choosing from a set of design solutions or copying an earlier design. Next, the second stage is the *novice,* who solves problems based on convention. A *novice* is aware of design and explores what it entails, which is a series of activities that are arranged in a formal process. They explore to understand the "rules of the game". They will take into consideration the facts they have been provided with by an expert, and follow strict rules according to a process they have been taught. Third is the *advanced beginner,* who solves based on the situation. At this level the problem solver realises that problems are situation-dependent and individual. They realise that standard solutions are not appropriate for every problem, and will therefore take rules as guidance, but may not strictly adhere to them. What differentiates this from the previous level is the acquisition of language to critique and discuss design. The fourth level is that of the *competent* problem-solver**,** who operates based on strategy. This designer can understand and handle common design problems that occur in their design domain. They use a different approach and may select elements of the problem space that are appropriate and interpret these accordingly. Rather than *reacting* to a problem situation, a designer at this level can actively steer the development of a problem statement. Here the designer has much more control over the situation, and can deepen their design practise over the course of several projects. Fifth is the *expert* who solves based on experience. An *expert* designer has a design approach or set of values that they are known for through their design work. They have an intuitive response and are able to recognise situations and how to approach them. At this level they will be much more involved in the problem space, and actively seek opportunities as well as take risks. Next is the *master* problem-solver, who develops new schemata. At this level the designer is innovating design practise, challenging established ways of working, and pushing the boundaries of the field. They are apt to share their knowledge through interviews and informal blog posts. Finally, the seventh level of problem-solver is that of the *visionary*, who explicitly aims to redefine the field. This person expresses radical ideas in design concepts, conference talks and publications, rather than in finished designs.

Beckett (2017:7) advocates for designers to use a speculative type of reasoning called "abduction". This is the idea that undetermined data can be temporarily "filled in" with reasonable assumptions in order to form hypotheses or advance a line of inquiry. This relies on the skills and intuition of the problem solver – again pointing to the importance of the person who will be solving the problem and what their skill level is.

3.1.3 Design problems and problem spaces

This combination of constraints and goals leads to the next thing that complicates design problems, namely, one cannot presuppose that there is such a thing as a set "design problem" at any one point in the design process (Dorst 2006:10). When considering design problems, there is a certain openness to the structure and it is difficult to determine the pattern of reasoning that connects the intentions,

requirements and needs to an artefact's form and intended use. This is considered the *undetermination* of design problems (Dorst 2003:2). There are two ways in which a problem can be undetermined. Firstly, Roozenburg and Eekels (1995) state that describing the needs, requirements and intentions of a design problem can never be complete as there can never be enough to define a "form". Secondly, Meijers (2000) points out that "requirements, needs, and intentions and structure" are part of different conceptual worlds.

Additional problems when trying to define a "design problem" include the fact that these cannot be known at any specific point in the design process (Dorst 2006:16) although they may be formed when a solution has been determined – this paradox again infers that design problems and solutions influence one another (Beckett 2017:7). Moreover, design problems are difficult to identify because they evolve during the design process (Dorst 2006:16). During this extensive exploration, problem and solution spaces are unstable until they are temporarily fixed by design interpretations (Dorst 2003:8). This "freezing of the context" can be problematic though, as it can result in solving the wrong problem (Dorst 2016:13). Finally, the concepts that are used to define a "design problem" shift as part of the design effort. Because of this, Dorst (2003:2) maintains that there is a large rift between "design problems" and "design solutions", which can easily make it feel impossible to arrive at an acceptable design solution. Even the word "acceptable" in this context is difficult to define. For whom does it need to be acceptable? The designer, the stake-holders, the people who will be using the solution? All of which potentially have very different requirements and acceptance criteria.

It is this "combination of problems" that creates a problem space, which Dorst (2015:2) identifies as "open, complex, dynamic and networked". The problem space can be defined by three characteristics (Dorst 2003:3). It is informed by facts that cannot be altered, and designers need to spend time in understanding the restrictions that have been posed by the problem space. Secondly, a large part of a design problem is undetermined, and the way the designer interprets it by selecting appropriate solutions adds undetermined aspects. Lastly, a designer can design according to their own style and taste, which is subjective and adds to the "undetermined" aspect. Thus, a problem never truly exists in any objective sense, instead, it is a combination of different problems centered around the general challenge (Dorst 2006).

Beckett (2017:11) argues that a problem and a solution do not exist or evolve independently, but are instead aspects (or "moments") of a single concept. He asserts that one starts with a "design scenario", which in itself contains a paradox. Within this paradox is the problem situation where "all the statements … are true or valid, but they cannot be combined" (Dorst 2006:6). Beckett (2017:7) further deliberates over the logic that a problem should precede a solution, although practise repeatedly shows that design problems do not follow this pattern. Pursuing a design problem tends to coincide

with discovering its solution - “a design problem does not appear to be properly determined until the determination of its solution” (Beckett 2017:7).

The role of the designer is thus to extract the paradox from a design situation. It is only when this contradiction between the problem (the situation as it is *at the moment*) and the aim (the situation as it *should* be) is opened up, that space is created where a possible solution can be created (Beckett 2017:11). Therefore, although initially illogical, a problem cannot be said to pre-exist its solution as the problem only comes into existence by means of being investigated. Here the role of the designer as problem-solver and problem-identifier is noted. Design includes problem solving, but cannot be reduced to it (Hatchuel 2001). Problem solving is one of the activities that forms part of design.

3.1.4 Wicked problems

Horst Rittel, a mathematician, designer and teacher, coined the term “wicked problems” in the 1960s (Buchanan 2008:15), describing them as “a class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications of the whole system are thoroughly confusing.” There are no clear solutions to these kinds of problems, which include things like poverty, corruption, and world hunger. Rittel identifies ten properties of wicked problems (1922:13):

1. Wicked problems have no definitive formulation, but every formulation of a wicked problem corresponds to the formulation of a solution.
2. Wicked problems have no stopping rules.
3. Solutions to wicked problems cannot be true or false, only good or bad.
4. In solving wicked problems there is no exhaustive list of admissible operations.
5. For every wicked problem there is always more than one possible explanation, with explanations depending on the *Weltanschauung* of the designer.
6. Every wicked problem is a symptom of another, "higher level," problem.
7. No formulation and solution of a wicked problem has a definitive test.
8. Solving a wicked problem is a "one shot" operation, with no room for trial and error.
9. Every wicked problem is unique.
10. The wicked problem solver has no right to be wrong–they are fully responsible for their actions.

Buchanan argues that most of the problems that designers face are wicked problems, as design does not have subject matter of its own separate from what a designer considers it to be – again pointing to Dorst’s earlier point that the designer influences the problem they are looking to solve. Design does indeed have many “wicked” elements, but whether this is a major factor depends on the project itself. A designer creating a poster to sell a product is going to have a vastly different problem space than a designer looking to improve radiology environments. In all likelihood, both face a budget and a timeline, but the former has much more definite and simple stopping criteria for arriving at a solution than the latter. This ties into the proposal that there are four “orders” of design in the twentieth century, as seen in Figure 24 (Buchanan 1992, 2001b).

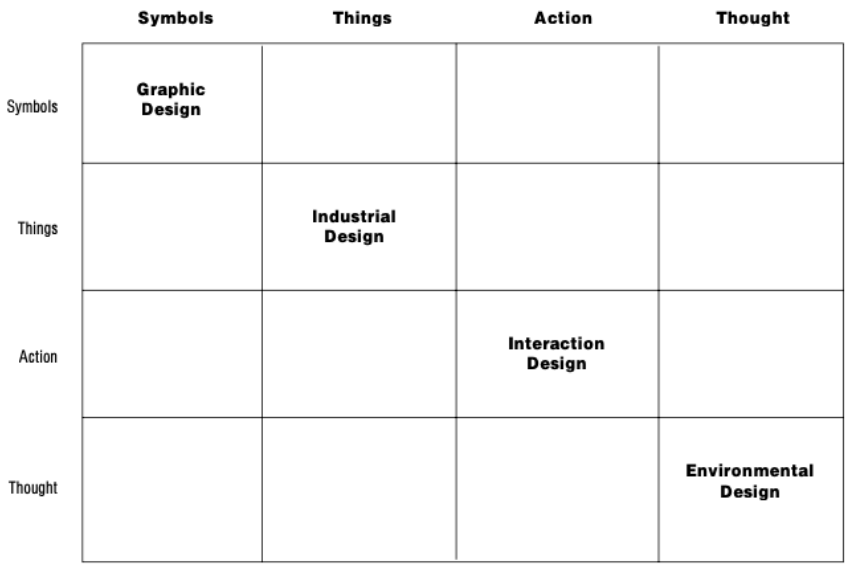

Figure 24: Four orders of design. (Buchanan 2001b:12).

The first order focusses on conveying information through visual symbols. This field has grown from graphic design, to be known as visual communication, and then communication design. Where it initially only encompassed the traditional medium of print, it now includes new media such as photography, film, television, sound and digital media. It is in this first order that the designer creating a poster finds themselves. The second order places focus on more tangible "things" in the sense of industrial or product design. This can include anything from clothing to tools, vehicles, machinery and domestic objects. The third order looks at activities and organised services and how people interact with those. This "interaction design" can refer to digital interfaces, or relate to logistics design and strategic planning.

The fourth order is the one this thesis concerns itself with, namely the design of an environment and guiding the players in that environment. It looks at complex systems or environments for living, working, learning and playing. Buchanan (1992:10) states that this fourth order, "… is more and more concerned with exploring the role of design in sustaining, developing and integrating human beings into broader ecological and cultural environments, shaping these environments when desirable and possible or adapting to them when necessary." It is in finding the balance between adapting an environment to the people and expecting the people to adapt to the environment where human-centered design becomes vital to consider. It can be used to find a middle ground. In a perfect world design systems and environments would be designed to be wholly ideal for the people within that space. But, in reality, we inherit systems and environments that may be resistant (or impossible) to change. For example, if the case study in Chapter Four had found that the physical working area was not architecturally ideal for the registrars, it would not be feasible or reasonable to suggest that it should be demolished and rebuilt to reflect a more human-centered environment. This would be costly and time consuming and would also mean a disruption of services to the hospital and patients.

Patients would probably need to be rerouted to a different hospital, which in turn would mean that the capacity of other hospital would be completely stretched. If the eventual value in a redesign and rebuild for registrars outweighed the inconvenience, cost and time, it would be worthwhile. This would be a utilitarian outlook, and it could be framed and interpreted differently if, for instance, one considered a deontological standpoint. This may suggest that it would be unethical to stop services to patients under any circumstances. Regardless of the ethical debates surrounding this, the reality is that a government would be unlikely to fund such an expense when it has much more pertinent things on which to spend money, such as supplying hospitals with gauze and antibiotics.

The higher the order of a design problem space, the more open-ended the problem is, and the more scope there is for *wicked* interference. In the context of this thesis, various issues encountered at Universitas Academic hospital fall into the *wicked* category. Public health, sanitation, safety, budgets and poverty are all issues that are beyond the scope of this study, but the role they play in the case study is acknowledged in Chapter Four. Other issues outside the scope of this study that were uncovered were a feeling of a lack of autonomy or ownership over decisions made regarding registrars' work. This is dealt with in greater detail in Chapter Four under themes, page 128.

3.2 Design thinking – Practical processes for tackling design problem spaces

Having considered why design problems are difficult to formulate, we turn to examine existing processes for approaching solutions. Design thinking has emerged as a field with various commercially-applied processes that can be used to investigate design problems. While there are many similarities, there are also distinct differences. The term "design thinking" was first mentioned by Simon in his 1969 book *The Sciences of the Artificial.* He describes many concepts that are now considered standard principles of design thinking, such as "rapid prototyping" and testing through observation (Dam & Siang 2020). In 1973 the notion of "design thinking" also appeared in Emeritus Professor of Mechanical Engineering, Robert McKim's book, *Experiences in Visual Thinking*. He focusses on how to create a more holistic form of problem solving by considering how to combine right- and left-brain thinking.

Nigel Cross discusses the nature of design problems in his 1982 paper *Designerly ways of knowing*. Subsequently Peter Rowe gives a systematic account of how designers think in architecture and planning in his 1987 book *Design Thinking.* In 1991 the internationally renowned design agency IDEO was co-founded by David Kelley (who took McKim's course at Stanford)[36] who also later co-founded the Stanford d.school in 2004 with Bernard Roth (Clancey 2016:24; Dam & Siang 2020). IDEO later

[36] McKim and Arnold, discussed in Chapter Two (page 15), are two of the pioneers of the human-centered design philosophy.

modelled its design process on the work developed at the Stanford Design School. The school's reigning ideology is "design thinking", a movement driven by the two insights. These are: one does not need to be a designer to think like one, and secondly, that in their drive to be professionally respectable, designers have narrowed the scope of their ambitions (Katz 2017:144). Last in this timeline is Richard Buchanan's seminal article on *Wicked Problems in Design Thinking* – discussed earlier in this chapter.

It is worth noting that the ability to frame a problem situation in a new and different light is considered one of the key characteristics of design thinking (Cross 2006; Lawson 2006; Schön 1987; Schön 1995). Framing and specifically "reframing" is discussed later in this chapter, under Dorst's proposed framework.

With the above in mind, we can consider the various practical processes for facilitating design thinking that have developed over the years. These processes that have evolved tend to share similarities in their structure and steps, and it is difficult to discern whether there is one specific "original" process that influenced the rest. It is notable that most of the processes are "owned" and have been created by commercial design companies, with the exception of the Stanford d.school which is part of Stanford University in the United States. Having a marketable, "unique" process for solving design problems in the design industry is something that sets a company apart and many may want to capitalise on. Hence the varied yet similar processes that are discussed below.

Each of the processes is analysed, discussed, and at the end of this chapter the insights are collated into one coherent novel process to be followed in Chapter Four for the case study. The main criteria for considering which aspects of the processes are to be included, are those that combine aspects that advance the human-centered intention of the overall process.[37]

3.2.1 Stanford d.school design thinking process

In the 2000s, a methodology for design thinking was pioneered and taught by the Hasso Plattner Institute of Design at Stanford – also known as the d.school. It involves five "modes" are shown in the hexagons in Figure 25.

[37] Emphasis is placed on aspects that place *people* at the centre of the processes.

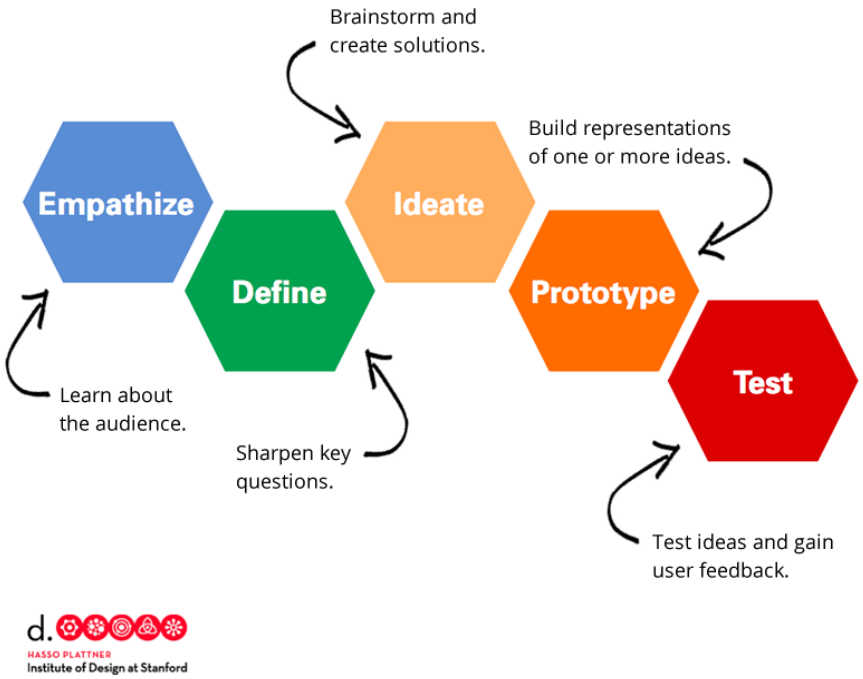

Figure 25: Modes in the design thinking process. (Stanford d.school 2011).

In subsequent years, the d.school has released a document titled the *design thinking bootleg*. It is intended as a deck of cards that can be printed out and used to facilitate the design thinking process. The introduction to the deck states, "In your hands you hold a Design Thinking Bootleg, a set of tools and methods that we keep in our back pockets, and now you can do the same" (Doorley *et al* 2018). The first five cards[38] describe these five "modes" while the following 38 cards[39] describe methods that can be used, such as interviews, brainstorming and affinity mapping, along with tips on how to perform these tasks and what to use them for. The structure and the simple, explanatory language used makes it seem that the intention of this deck of cards is to allow anyone to facilitate the design thinking process.

The "modes" that form components of design thinking are elaborated on below (Doorley *et al* 2018):

i. **Empathise**

   The foundation of human-centered design is empathy, and requires you to learn users' values, as the problems that are being solved are rarely your own. This can be done by observing, engaging, and immersing yourself in the users' worlds.

ii. **Define**

   This mode is intended to unpack insights and findings from the empathise mode so that a meaningful challenge can be scoped. An actionable problem statement – a "point of view" –

[38] The cards are intended to be printed back and front, thus five cards consist of 10 pages.
[39] Again intended to be printed double-sided, thus 76 pages.

should be defined, which serves as a design vision for the specific users you are designing for. This perspective aims to reframe the challenge at hand to serve as a springboard for solution-generation.

iii. **Ideate**

Here the opportunity exists to generate radical design alternatives. The idea is to "flare" and expand or "go wide" instead of "focussing" and explore a wide array of ideas. During ideation the team can fluctuate between "focussing" and "flaring".

iv. **Prototype**

Prototyping is a means to represent ideas so that others can experience and interact with them and give feedback. Prototypes can take a variety of physical forms, ranging from sticky notes, a role-playing activity or built objects, to name just a few. The intention is to have a low-cost, low-resolution visualisation that can spark conversations among the design team, the users, and others.

v. **Test**

Testing allows for getting feedback, continuous learning, and refining solutions. It is an iterative process in which low-resolution prototypes are tested in the appropriate contexts of the user's life.

Overall, this process provides valuable guidelines as a start to the design thinking process, and at first glance this process seems straight-forward and easy to use, due to the succinct descriptions, and simple language used. It does simplify the design process considerably which means that some key considerations are left out. However, it does fail to take many nuances into consideration, as discussed below.

Mode (i), *empathise*, is referred to as the foundation of human-centered design. Nowhere in the document up to this point has human-centered design been mentioned or discussed. As has been discussed in Chapters Two and Three, these are separate concepts that are often used together. Conflating them may lead to confusion for non-designers or less experienced designers, as is discussed later in this chapter under *Democratising design*.

Mode (ii), *define*, assumes that a problem can be defined from the outset, which is problematic in relation to problem areas and the paradox that problems and solutions present. The concept of "reframing" here is certainly interesting, and is discussed in more detail later in this chapter in relation to Dorst's similar concept of "reframing".

Mode (iii), *ideate*, suggests a similar way of working to the Double Diamond process which is discussed later in this chapter. It appears that care has been taken to use different language, by stating words like

"flare", "go wide", and "focus", instead of "diverge" and "converge" which is associated with the Double Diamond process. As the *bootleg* document was released subsequent to the Double Diamond model, it is possible that it borrowed from it or, at least, was influenced by it.

Mode (iv), *prototype*, points out that this approach is intended to spark conversations among various people. What it fails to address is what priority the feedback is meant to be given in. Who should be listened to primarily? Other designers or the stakeholder who commissioned the project? Perhaps the end-users of the project, or the "others" that are mentioned? Who are these others? Are they laymen unrelated to the project? Is it the designer's mom? The vague language makes it difficult to discern how the designer is meant to incorporate this feedback. It could also be that this process is meant as a general guideline, and that designers should use their own discretion regarding the way ahead. This seems most likely.

Mode (v), *test*, is the first time an iterative process is mentioned, and it is the only "mode" to be mentioned as iterative. Subsequent processes discussed in this chapter discuss from the outset that they are iterative, and not linear.

In practice

As mentioned, the visualisation of the design thinking process in Figure 25, and indeed every process listed in the rest of this chapter, is linear and neatly consecutive, as is the case in the left side of Figure 26. Meinel, Leifer and Plattner (2011:xiv) acknowledge that the process in practise is probably closer to the right side. This figure uses an older version of the design thinking process as the labels (hence the difference in steps), but the principle holds.

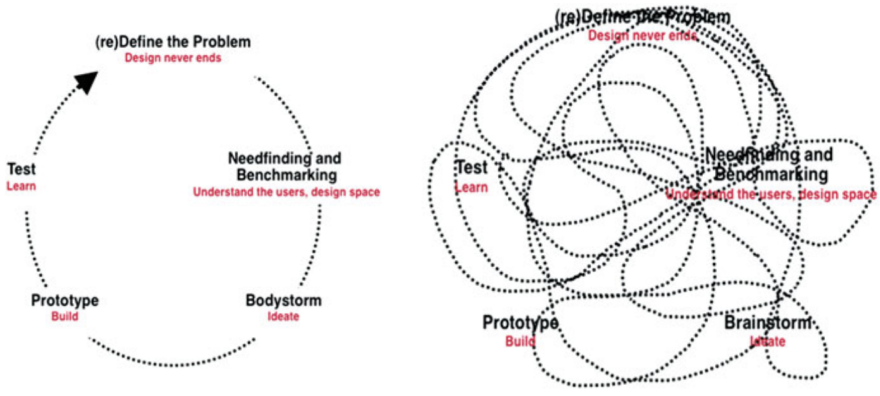

Figure 26: Design thinking process in theory (left) vs in practice (right). (Meinel *et al* 2011).

With regard to this thesis

For this thesis the first three phases of this process work well to advance the human-centered intention of the overall process, and have therefore been included. This includes *empathising* with radiologists and registrars, *defining* what their exact needs, pain points and frustrations are, and *ideating* around possible solutions to the challenges they face. However, the last two phases, *prototyping* and *testing,* present a challenge. While prototyping is a process generally undertaken by the designer and does not require external input, the value of this phase only becomes explicit when something tangible exists to get feedback from during the *testing* phase. It is the testing phase that is problematic in the context of this thesis. As has been mentioned, registrars have little time available and testing prototypes can be a time-intensive process. Also, the hospital environment in which registrars find themselves does not lend itself to the easy testing of solutions. A hospital is a complex combination of systems and processes. These range from regulatory and legal, imposed by the government and the governing body for medical professionals in South Africa,[40] to clinical processes defined by best practice for each discipline, and more. As discussed in Chapter Four, the solutions suggested for the radiology space involve environmental and systems interventions that would need to be implemented and experienced by registrars in order for feedback to be generated. Trying to incorporate actual interventions that have no guarantee of success into an environment that is fast-paced and high-stress was therefore deemed not realistic or responsible to this researcher for this phase of this study due to time and Covid-19 restrictions.[41]

Originally, I proposed obtaining feedback from the registrars after each step of the design process in the case study. This was then reduced to receiving feedback after the solutions had been suggested – effectively testing hypotheses. After realising that it took 9 months of coordination before I was even able to interview subjects for this study, the idea of adding an additional step seemed unrealistic and was abandoned in favour of completing this study in the timeframe allowed. I also did not want to add undue stress and effort on top of registrars' already busy schedules. The proposed solutions that have been hypothesised will be sent to the head of the diagnostic radiology department at Universitas Academic Hospital after this thesis has been concluded. The intention is to continue with the research process and get feedback on whether the solutions are feasible, and how they could be implemented without disruption to the current workflow. This is relegated to future research.

3.2.2 Interaction Design Foundation design thinking process

The Interaction Design Foundation iterates on the Stanford d.school visualisation to include arrows that indicate moving back and forth between the different steps of the design thinking process to

[40] This governing body is called the Health Professions Council of South Africa (HPCSA).
[41] As detailed under *Next steps* on page 156: once buy-in and permission has been obtained from the department detailed in the case study, the intention is to implement the interventions suggested.

indicate the iterative nature thereof (Figure 27).

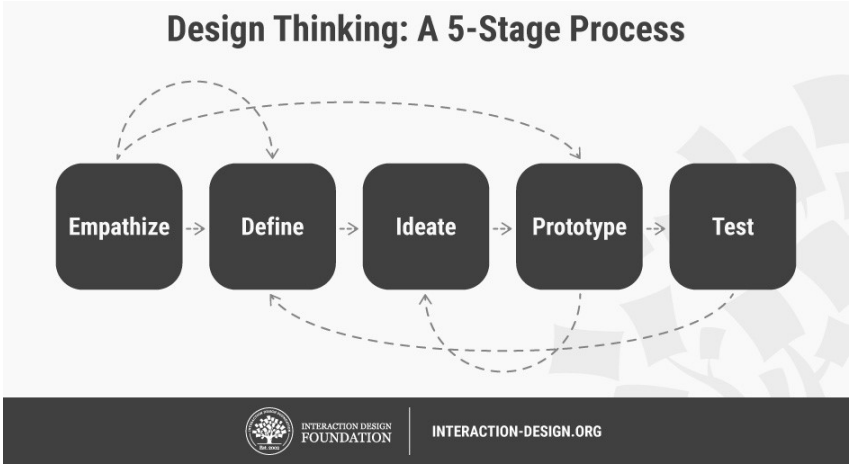

Figure 27: Steps in the design thinking process. (Interaction Design Foundation [sa] a).

The Interaction Design Foundation (2021) stresses that these are *stages* and not sequential steps. They can be performed in whatever order fosters the deepest understanding of the users and what their ideal solution or product would be. The first step is given the title, *Empathise*. The focus of this step is to identify the research needs of the people who the designers are working with. It aims to empathise with the people being designed for and gain an empathetic understanding of the problem that needs to be solved. Typically, this is done through research. Empathy is crucial to the human-centered design process as it enables designers to step away from their own assumptions, step outside of their own frame of reference, and gain insight into real people and their needs. The next stage is termed *Define* and endeavours to state the needs and problems of those involved. Findings from stage 1 are analysed in order to define the core problems and goals for the project. These definitions are called "problem statements". Next, *personas* can be created before continuing to stage 3. Stage 3 is termed *Ideate*, and looks to create ideas. Once problems have been defined and goals set, innovative thinking can assist in devising potential solutions. Brainstorming is useful in this step in order to expedite the various potential solutions. Stage 4 is given the title *Prototype,* where one starts to create solutions. This experimental phase aims to establish the best possible solution for each problem definition and encourages the creation of inexpensive, scaled-down versions of solutions. Lastly, Stage 5 is termed *Test*, where solutions are tested by the actual users, stakeholders, other designers, or laymen, to get feedback. By understanding how people use the solutions that have been created, it can quickly be established which solutions work, what needs to be changed and adapted or rethought.

The Interaction Design Foundation credits the design thinking process to the d.school, hence the exact same stages are used, with the descriptions of the stages expanded in order to include their own interpretations.

The language used in these process descriptions appears to be aimed at existing designers, as terms such as “personas”, [42] “brainstorming”, [43] and “prototypes” [44] are used without explanation. These words are design jargon that experienced designers would be familiar with and know how to implement without additional explanation.

No methods are supplied for these stages, presumably as more experienced designers would already know what methods can be utilised.

With regard to this thesis

With the stages being the same as the d.school process, the same critiques apply. The first three stages – *empathise*, *define*, and *ideate* – are included for the process created at the end of the chapter. Again, *testing* was deemed too time-intensive and disruptive to demand from registrars, which meant there was no point in *prototyping* the suggested solutions.

3.2.3 Live Well Collaborative Process Model

The Live Well Collaborative (2021a) is a non-profit organisation founded in 2007 by the University of Cincinnati, and Proctor and Gamble. It utilises multidisciplinary teams composed of faculty and students from the University of Cincinnati to create design solutions for their industry partners.

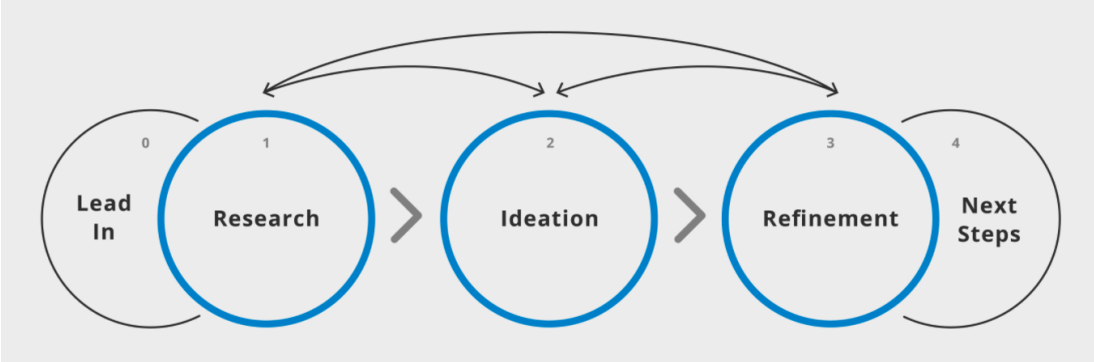

Figure 28: Process Model. (Live Well Collaborative 2021b).

[42] A persona is an archetype of a person that helps designers to empathise by understanding their business and personal contexts, goals, and pain points (Pesot & Plantenberg [sa]).
[43] Brainstorming is a method that can be used to generate ideas to solve design problems. These ideas are generally clearly defined, and it is conducted in controlled conditions in a free-thinking environment (Interaction Design Foundation [sa] a).
[44]Prototyping is an experimental process where ideas are created in tangible form. Prototypes can be drawn on paper, created physically or digitally, and can be created in a variety of fidelities, depending on the requirements. The intention is to use these prototypes to validate designs and ideas with users (Interaction Design Foundation [sa] c).

The overarching structure of this process model (Figure 28) is similar to the d.school design thinking model, with the notable addition of a "Phase 0 – Lead in" upfront. During this phase the multi-disciplinary team to be working on the project is identified - this has been absent in other models. This phase also requires the team to establish who the target consumer is, to agree on the project scope, objectives and deliverables, and the project schedule and key interaction dates.

Attempting to define the scope, objectives and deliverables before the project is a problematic venture, as the problem space itself has not yet been investigated. How can outcomes be defined when a problem hasn't been defined or even identified yet? As discussed earlier, a problem space evolves as it is being investigated and influences the results, therefore this cannot be done upfront. It would be pure guesswork at this stage. The overall objective of this process is to improve radiology environments, which starts by placing an emphasis on the *people* who are in the space.

Phases 1-3 follow the same structure as the d.school design thinking model, and a Phase 4 is added for "next steps". This phase aims to assess whether the results have met the deliverables, measure the success, document and archive the process, as well as determine the next steps. "Measuring success" and "assessing deliverables" are very vague items, and no clear guidance on how to achieve this is provided. Prototyping and testing is absent from this model, which is vital in other models.

As part of their training video on how to utilise this process model, the Live Well Collaborative has a 4-minute section on "understanding designers". The roles of the rest of the multidisciplinary team are not explained and, while this may be well-intentioned to educate non-designers on what to expect and how to interact with their design team, it serves to present the designer as the "other" [45] in this scenario, and removes them from the rest of the team. This may be problematic if it causes difficulties for the team to work as one cohesive whole.

With regard to this thesis

The *lead-in* phase of this process places an emphasis on planning and looking at the people conducting the research – an aspect that has been missing from previous approaches. Here, it serves to further the human-centered intention of my process which is why it been included for the planning aspect, both in defining the problem (the PhD project proposal) as well as the target audience that was identified (radiology registrars at Universitas Academic Hospital in Bloemfontein). There is no true multidisciplinary team working on this project though, as a solo researcher (myself) conducted the research, albeit with the assistance of research participants (the registrars and radiologists), as well as

[45] The concept of the 'other' originates from phenomenology, and serves to objectify and alienate those who are identified to be "different from the norm". In this case, designers.

a research supervisor who provided guidance and input. Defining the scope, objectives, and deliverables as part of this phase has also been included, although it will not be a simple answer.

Research and *ideation* have been utilised as mentioned under the previous processes. *Refinement* is difficult to implement without further involvement from registrars, and has been left out. *Next steps* is an aspect not present in previous processes and, while it was originally intended as a way to assess whether the results have met the deliverables, which is not applicable in this scenario as no set goals were set out at the beginning, it has been included in a more literal sense. It is literally the "next steps" that can be taken after this project, much like "further research or work" is always included at the end of a thesis or dissertation.

3.2.4 Design Council's double diamond process

The Design Council's "double diamond" process is named after the way it is visualised, as can be seen below in Figure 29. This process, launched in 2004, entails divergent and convergent methods of thinking. First diverging to discover insights into the problem, then converging to define focus areas; diverging again to develop and explore potential solutions, and finally converging again to deliver solutions (Design Council 2004).

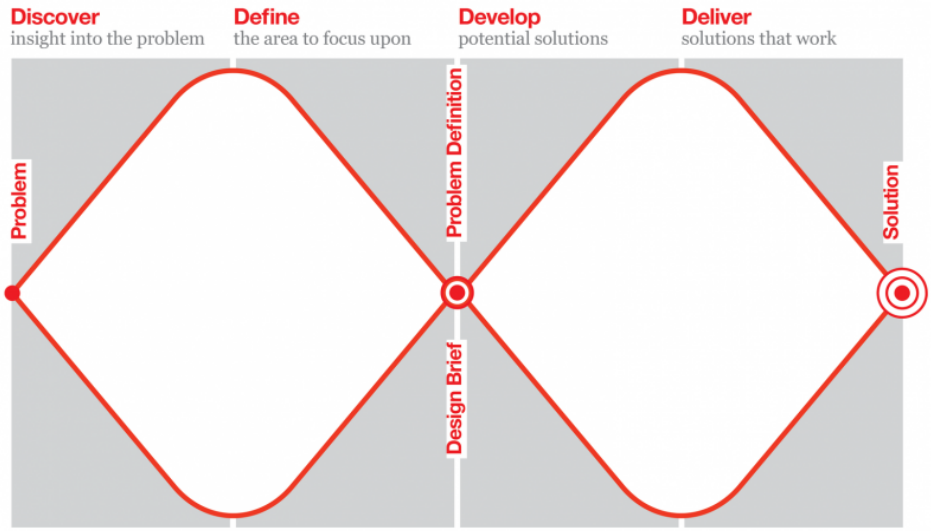

Figure 29: Double diamond design process. (Design Council 2004).

- **Discover**

  The first diamond aims to help people understand, instead of them assuming what the problem is. It encourages designers to speak to and spend time with those affected by an issue.
- **Define**

  Insights from the previous phase help to define the issues in a different way.

- **Develop**

  This second diamond seeks to find different ways of thinking relating to the clearly defined problems from the previous phase. It encourages co-designing with various people and seeking inspiration from unexpected places.
- **Deliver**

  Part of delivery involves testing various solutions on a small scale. Of those solutions, ones that do not work must be rejected, and ones that do should be improved.

The Design Council, as with the Interaction Design Foundation, also emphasises that the process is not linear as it may appear on the diagram. Testing and making are vital parts of discovery, and can send one back to the beginning. No idea is ever "finished", which means the process is continuous because products and services are usually being iteratively improved upon.

In 2019 the Design Council (2019) 'evolved' the double diamond design process, now named the "framework for innovation". It keeps the original methodology, but adds more supporting structures, as seen in Figure 30. Namely *Design Principles*, a *Methods Bank*, and incorporating overarching considerations for *Engagement* and *Leadership*.

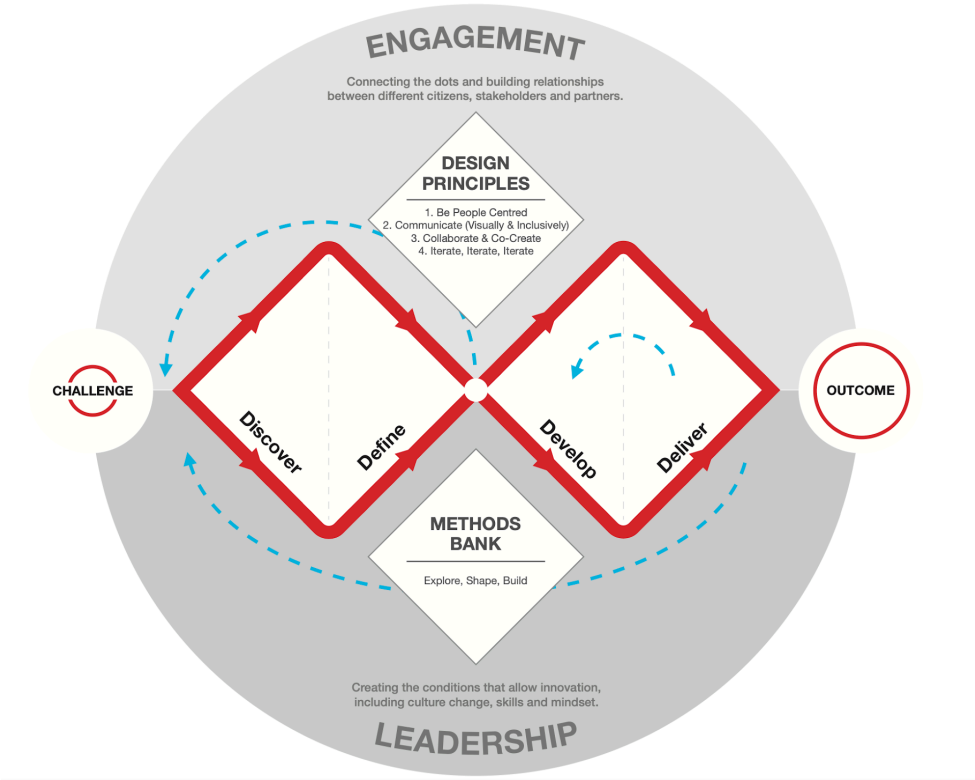

Figure 30: Evolved double diamond design process: the framework for innovation. (Design Council 2019).

This model aims to make the design process accessible to designers and non-designers alike by including key design principles, design methods, as well as the ideal working culture "to achieve

significant and long-lasting positive change". This appears to be based in business and sales jargon as there is no substantiation to this "claim".

There are four design principles for this framework (Design Council 2019):

- *Put people first.* Start with an understanding of the people using a service, their needs, strengths and aspirations.
- *Communicate visually and inclusively.* Help people gain a shared understanding of the problem and ideas.
- *Collaborate and co-create.* Work together and get inspired by what others are doing.
- *Iterate, iterate, iterate.* Do this to spot errors early, avoid risk and build confidence in your ideas.

This first principle of "putting people first" points to the framework being underpinned by a human-centered design philosophy. The other principles reflect similar principles to those of human-centered design.

The "methods bank" groups 25 different design methods into the four diamond steps, and applies it into three areas: explore (challenges, needs and opportunities), shape (prototypes, insights and visions) and build (ideas, plans and expertise). In a website article the Design Council lists various design methods under the diamond steps, but never explains how this relates to the three "areas" (explore, shape and build), or even mentions them.

Lastly, the Design Council (2019) states that it is imperative to create a "culture of success" i.e. the circle surrounding the other processes in Figure 30. Solving problems involves not only coming up with ideas, but also collaborating with organisations, partners and other people. The aspects that enable a solution to be successful are *leadership*: encouraging innovation, building skills and giving permission for experimentation and learning; *engagement:* interacting with the people who are delivering and receiving ideas, and also developing connections and building relationships with others.

The arrows that have been added to the figure attempt to indicate iteration and that it is possible to go back to a previous step at any time in the process. Unfortunately, this comes across as an afterthought, as the original diamond structure does not lend itself to seeming iterative.

This approach, while initially simple, has evolved to be quite convoluted, and not fully considered. It appears to be trying to teach non-designers how to perform the design process in as much detail as possible, without taking sufficient time to explain it. The revised diagram is complex and difficult to engage with.

With regard to this thesis

While the Double Diamond approach reiterates many of the same concepts in the process that have been mentioned previously, it adds a new concept: the idea of diverging and converging during certain stages. This is implied in other processes, but the Double Diamond makes it overt by visualising it, which makes it easier to follow. While in a divergent phase, there are no "bad ideas" as no critical evaluation is applied. This serves to advance the human-centered intention by making data gathering and idea generation easier in a sense, as nothing is irrelevant or unnecessary. This aspect has therefore been included in my process.

3.2.5 Google Ventures Design Sprint

The internationally renowned search-engine-turned-cutting-edge-software-company Google devises a six-step process which they term a "design sprint".[46] Each phase is explained, and different methods are discussed which can be used during each phase. An emphasis is placed on planning for the design sprint and Google advises that at least one day should be spent planning for each day of the sprint. The time needed for the sprint is determined by the needs and goals of the team.

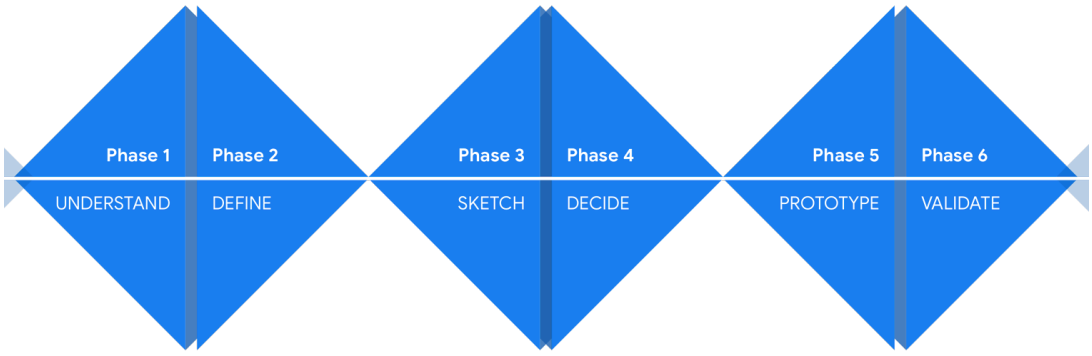

Figure 31: Design sprint methodology. (Google [sa]).

The six phases can be seen in Figure 31, and are elaborated below (Google [sa]). The first phase is that of *Understand.* This phase aims to create a shared understanding between all participants. Examples of methods to be used during this phase are user journey mapping, experience mapping, user interviews, empathy-building exercises and lightning talks where experts from across the business are invited to describe the problem from the viewpoint of the user and business competitor as well as the

[46] A "sprint" is a term used in Agile software development, used to refer to a short, set time period during which a team works to complete a set amount of work (Atlassian [sa]). A team can determine for themselves how long each sprint will be – it is usually between one and four weeks.

technological angle. The second phase is *Define.* During this phase the team aims to evaluate everything learnt during the previous phase to establish a focus. A specific context is established, as well as desired outcome. A focus is chosen for the sprint, as well as success metrics and goals. Methods to be used include success metrics and signals, business model canvas, assumptions mapping, future press release and design principles. The third phase is *Sketch.* The aim of this phase is to generate and share a broad range of ideas. It is an individual exercise where many ideas are created, and then narrowed down to a single, easily understandable "solution sketch" per person. Methods to be used include crazy 8s, solution sketches, and boot-up note taking. The next phase is *Decide.* This phase is intended for the team to finalise the concept to be prototyped. Each person shares their solution sketch, and the team reaches a consensus on a single idea by means of decision-making exercises. Methods to be used are dot voting, silent voting, heatmap voting, decision matrices, and action planning. The next phase is *Prototype.* The prototype phase is where the team works together to create a prototype of the concept that was decided on in the previous phase. A design sprint prototype does not have to be high fidelity, it just needs to be realistic enough to get an authentic response from a participant during the *validate* phase. Methods to be used include storyboarding, prototyping with version control, and prototype playback. The last phase is that of *Validate.* This phase seeks to place the prototype in front of users to get real feedback on the solution that has been generated. Feedback is gathered from users as well as stakeholders and, if relevant, technical feasibility reviews are conducted. This phase ends either with a validated concept or an invalidated concept that can be improved on. Methods to be used include usability studies, cognitive walkthroughs and stakeholder and technical reviews.

In the introduction it is recommended to use all six phases, but there are some situations where shorter workshops can be run using these methods. Google [sa] suggests that, "[t]he important thing is that you pick the methods that work best for your specific goal and plan the number of days for your Sprint accordingly." While this allows for a lot of flexibility, it means that this design sprint process could potentially require a lot of planning. Moreover, the level of the problem-solver would also need to be quite advanced, in order to allow them to interpret the findings, find meaning and formulate structure out of separate methods. In the FAQ for this process it is mentioned that design sprints may not be appropriate for every problem. This is the first and only time it is acknowledged by any of the processes.

Looking at the structure of how the process is visualised (Figure 31), it is reminiscent of the Design Council's double diamond process with divergent and convergent stages, although it is not explicitly mentioned. The phases themselves are more in line with the Stanford d.school design thinking process and the Interaction Design Foundation's design thinking process. Although instead of five "modes" or "stages" there are six phases – the additional phase coming in by splitting the *ideate* mode/stage into

"sketch" and "decide". This places greater emphasis on both the creation of ideas, as well as narrowing those ideas down into a practical concept to be taken through to the *prototype* phase.

With regard to this thesis

This process again echoes previous processes, and *Understand* and *Define* are already included in the process. *Sketch* is suggested in place of *ideate*, which is not necessarily applicable in this instance, since the focus of the solutions in Chapter Four are not necessarily tangible design artefacts or interfaces, which is what sketches would traditionally be used to depict. The terminology of *ideate* is therefore kept instead. The diverging and converging depiction of stages is already included. This process places a heavy emphasis on working in specific time increments, which is more applicable to software development processes, not design research, and these aspects have therefore not been used to form a new process for this study.

3.2.6 The IBM Loop process

In 2018 IBM introduced its "Loop" approach, which is marketed as part of its "Enterprise Design Thinking Framework", a phrase coined by IBM. It is explained as "a framework to solve our users' problems at the speed and scale of the modern enterprise." It does not explain how it is different from other design thinking approaches, or why an enterprise, a large or complex company, would need a different approach from any other company.

The approach uses the infinity symbol (∞) to visually represent the continuous cycle of *observing*, *reflecting* and *making* that makes up its phases (Figure 32). This is effective in relaying the iterative nature of this process, more so than previous approaches that simply incorporate arrows. This symbol does also have an inherent flaw though as it does not indicate a starting or stopping point for the design or problem-solving process.

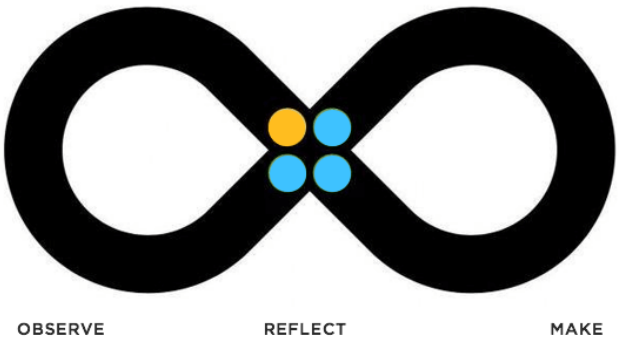

Figure 32: The Loop. (IBM [sa]).

There are three phases described by IBM ([sa]). The first phase is *Observe*, and encouragement is given to "[i]mmerse yourself in the real world". During this phase users should be observed in their own world, as it is difficult to form a thorough understanding of real-world problems while sitting at a desk or a conference table. Understanding is not something that can be delegated, everyone in the team needs to have the chance to see the users' world in order to empathise with their experience. The second phase is *Reflect.* The intention of this phase is to allow team members to synthesise what they've learnt, share ideas, and think how they want to move forward. Ask and give feedback, and be flexible in responding to change due to new insights. The third and final stage is *Make*, i.e. "Give concrete form to abstract ideas". Instead of waiting for ideas to be "perfect", they should be shared with the team and put into the world to get feedback. The faster you get your ideas out, the faster you will learn from them, whether they are successful or not.

The yellow dot indicates a focus on user results – putting people's needs first, while the three blue dots represent multidisciplinary teams. The placement of the dots would indicate that they only come into play during the *Reflect* phase of the loop, but realistically it may have been a stylistic decision on the part of the creators of the design to make it seem "neat" while keeping it central to the process.

While the sentiment expressed in the O*bserve* phase is well-intended, namely, "Immerse yourself in the real world", and does serve to drive the idea that understanding is difficult to gain when not engaging with users in their own environment, the language used implies that working in an office at a desk is not part of the "real world". Not all designers or people solving problems are able to be "on the ground" or "in the field", and this step essentially tells designers that their work is unlikely to meet any relevant standards if they do not take the trouble to look at things *in situ*.

The second phase, *Reflect*, makes a strong case for sharing insights, taking time to consider if you're on the right track, and being flexible to adjusting expectations when new information is uncovered.

Lastly, the *make* phase builds on the idea of "rapid iteration" that has been seen in previous models. The risk here is being stuck in a never-ending loop of ongoing repetition. No stopping criteria are given as to when a product or service is ready to be implemented or created for real. Right at the end is it mentioned that, "once you've committed to an idea, turn your intent into an outcome". If commitment is the only criteria, who is commitment required from? Stakeholders? Designers? End-users or consumers? Each of those groups may have different requirements that they would like to commit to, so it is uncertain who has the power to make this final decision according to this model.

With regard to this thesis

As has been discussed in Chapter Two, observation was not possible during this project, due to the ongoing Covid-19 pandemic. The implication of this is that this project is lacking because of it, which is certainly not the case, as can be seen in Chapter Four's case study. Indirect observations and insights have been gained by means of interviews with registrars, that have led to a valuable understanding of their working environment, and the creation of solutions. The process of *reflection* was incorporated into the define and ideate phases. The *make* phase was unfortunately also not possible, as has been discussed earlier as this process was deemed not suitable to be followed for this project.

3.2.7 IDEO Field Guide to Human-Centered Design: Design Kit

The IDEO (2015) design kit describes itself as, "A step-by-step guide that will get you solving problems like a designer". This implies that, as is the case with the Design Council's methodology, the intended audience for this guide is primarily non-designers. It consists of three phases namely, *Inspiration, Ideation* and *Implementation.* The *Inspiration* phase is intended to create a better understanding of people, to observe their lives, and to listen to their hopes and desires. The *Ideation* phase considers everything observed and heard in the previous phase which is used to generate ideas, identify opportunities and test and refine solutions. Lastly *Implementation* is when the solution is brought to life by getting it to market and optimising its effect in the world.

IDEO (2015) proposes that this process follows divergent and convergent thinking in the different phases, which is reminiscent of the Double Diamond approach discussed earlier in this chapter, just differently articulated (Figure 33).

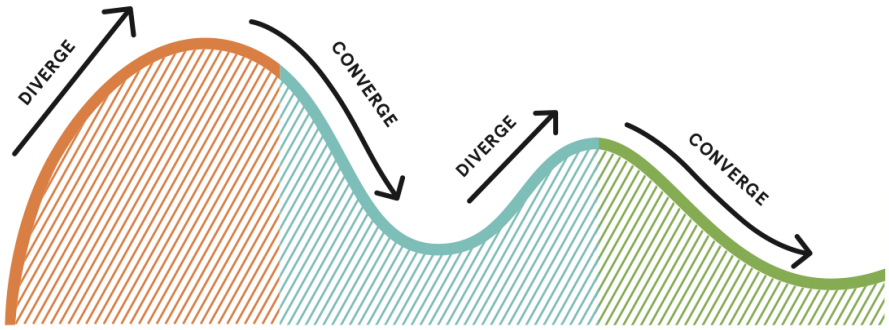

Figure 33: Visualisation of the IDEO process. (IDEO 2015).

The rest of the design kit consists of 57 methods described in detail with exercises and activities for each, that support the human-centered design process.

Whilst easy to engage with, the real value of design is not explained in this toolkit; it is instead reduced to a formulaic process to follow. This confirms that the visual nature of these processes is aimed more towards non-designers than designers.

With regard to this thesis

As this researcher is an experienced designer with more robust processes at my disposal, aspects of this process were not included.

3.2.8 ISO human-centered design process

The International Organisation for Standardisation (ISO 9241-210:2019) defines five essential processes that need to be undertaken in order to incorporate human-centered design into the software development process (Figure 34). These are: the human-centred design process must be planned; the context of use must be understood and specified; the user and organisational requirements must be specified; designs and prototypes must be produced and a user-based assessment must be carried out.

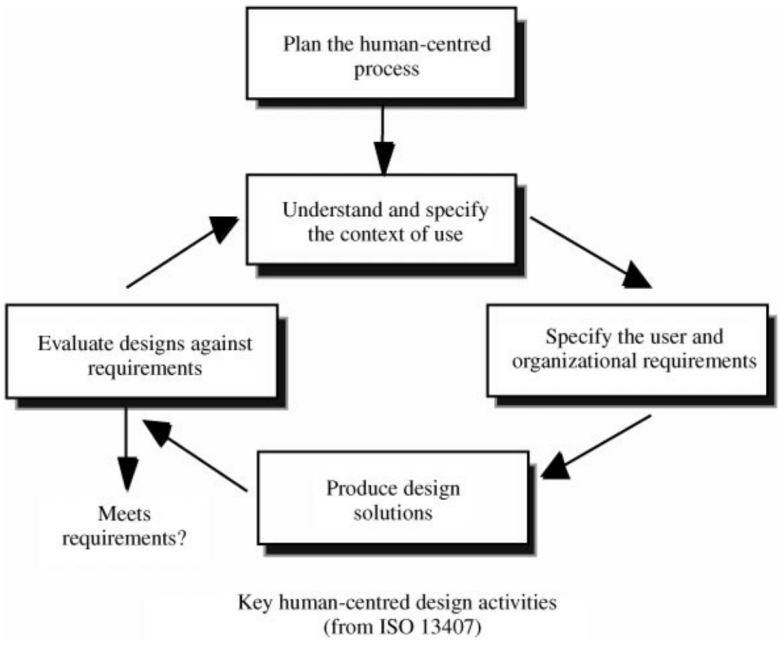

Figure 34: The human-centred design cycle. (ISO 1999).

The process outlined here is structured and while it does imply that the design process is iterative through the use of arrows, it also implies that one would need to start from the beginning if the first iteration of designs were not well-received or did not work as intended. Although this research study does not focus on software development, the design process is still valuable to consider.

The first step in this process – planning – seems to imply that a set structure will be followed, with no room for iteration or changes. This is problematic because the process tends to change as the problem paradox is explored further.

Secondly, the intention is to understand the *use*, and only in step 3 is the *user* considered. Since we know that the person using a system influences the way it is used, it seems counter-intuitive to investigate the *use* first. This *use* may be presented as the best-case or ideal *use,* which is rarely how a system is actually used. If it were, someone would probably not have been brought in to look at improving it. So, while it provides valuable steps to consider, it is used in conjunction with other methodologies to form a more comprehensive framework.

With regard to this thesis

The *planning* aspect of this process has been included as part of the *lead-in* phase, and *understanding and specifying the context of use* as part of the *empathise* phase. *Specifying the user and organisational requirements* is difficult because a design problem and its solution co-evolve, so it is difficult to define what the requirements are without knowing what the solution is. This phase echoes aspects of the *lead-in* phase from the Live Well Collaboration process model, which endeavours to define the scope, objectives and deliverables, and has been incorporated into my process as one combined section. *Producing* design solutions is part of *ideate*. *Evaluating* designs against requirements is difficult, but understanding what solutions aim to achieve will help to determine if and when they have met requirements.

3.2.9 Dorst's Reframing

In his book *Frame Innovation*, Dorst (2015:74-79) suggests "reframing" as a way to approach design problems in a different way. It consists of nine steps and differs vastly from the previous frameworks mentioned, as can be seen in Figure 35. The concept of "framing" is generally associated with higher levels of expertise (Akin 1990; Cross 2004; Lawson & Dorst 2009; Lloyd & Scott 1994), and ties into Dorst's earlier discussion on the importance of the expertise of the problem-solver in formulating the design problem space.[47] While Dorst is not the first to suggest "framing" as a means of creating new solutions for design problems, he does articulate it in a usable framework.

[47] The idea of a "frame" was initially introduced in the field of artificial intelligence (Paton & Dorst 2010), while the idea of a "frame" in design theory is largely based on Schön's work on reflective practice (Cross 2004; Dorst 2006).

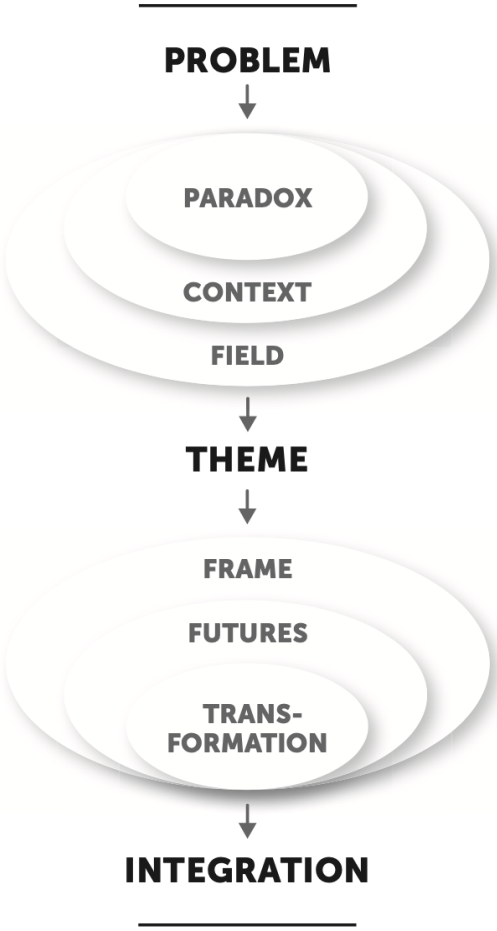

Figure 35: The frame creation process. (Dorst 2015:137).

The first step in Dorst's (2015:74) process is determining the *archaeology of the problem situation.* This involves investigating the problem in depth as well as previous attempts to find solutions for it. It provides insights as to how the problems came to be and explains the dynamics of the organisation over time. It also helps to set the boundaries and non-negotiable issues, as these will guide and limit the creation of new frames later on.

Next, it is vital to *establish the core paradox* (Dorst 2015:74). Understanding what makes the problem situation hard to solve starts to provide clues on how it may be addressed. It follows a series of "because" statements to point out the paradox. For instance, I've crafted the following example:

Because I do a lot of research, I learn many things.

Because I learn many things, I learn of many more things I do not yet know.

Because I know that there are many things I do not know, I do not know how much I do not know.

The first and last statements in this line of thinking are at odds with one another and therefore create a paradox.

Once this has been concluded, the *context* of the overall space must be investigated. It is vital to have a thorough understanding of how, when, where and by whom problem spaces are used and created. Without this context, the problems being solved may possibly be the wrong ones. It is therefore important to understand contextual information such as practices, scenarios, workload, support available and interruptions (Dorst 2015:75).

Next, the wider *field* is investigated. Once a reasonable overview of the problem space has been achieved, the scope needs to be widened to include the *field*. This is a realm that includes intellectual, cultural and social aspects. It allows consideration for anyone who may interact with the problem, whether actively or passively at some point in time, not just the key players (Dorst 2015:75).

Following this, *themes* need to be established that permeate the context and the field. In analysing themes, there is a desire for a deeper understanding of the needs, experiences and motivations of those involved. Theme analysis as used in phenomenology can be used, but deeper themes that link the human (cultural) domain and the technological realms can also be useful. Insights from step 4 will also be used to identify themes (Dorst 2015:76).

From here *frames* are created. Applying new frames to the existing problem space is the heart and soul of what Dorst aims to achieve through his paradigm. It requires one to think of a current problem situation *as if* it were something else, which may lead to a different way of thinking.
Dorst (2016:78) states that it can be written as follows:

If the problem situation is approached *as if* it is ... , *then* …

An example of this application would be as follows:

If the lack of knowledge is approached *as if* it is an opportunity to learn, *then …*

We should make it easy to access accurate information

Numerous frames can be written out and variations that can lead to different implications and interpretations.

Dorst (2015:100-109) also includes ten principles for frame creation:

1. *Attack the context.* Accept that the design problem space cannot be solved directly, and needs to be critically assessed before the problem itself can be attacked.
2. *Suspend judgement.* Do not punish stakeholders for the situation they find themselves in. They may not be aware of the situation they find themselves in or how they may have contributed to it. As Einstein said: “A problem can never be solved from the context in which it arose”.
3. *Embrace complexity.* Avoid simplification, as it can remove important context from the problem space.

4. *Zoom out, expand and concentrate.* Remember the bigger process you are engaging with. Reframing is a constant process of zooming in and out of different areas. Reflect on what has been discovered and consider how that can be applied in various areas.
5. *Search for patterns.* Look at what people *do*, not what they *say*. Finding patterns are often integral to reframing problems.
6. *Deepen themes.* Creating themes is an abstract activity that focusses the depth and quality of the end result.
7. *Sharpen the frames.* An effective frame evokes a clear picture in the mind for all major stakeholders.
8. *Be prepared.* Do not try to rush the process - become intimately acquainted with the research.
9. *Create the moment.* Once the preparatory work has been completed, the team, consisting of team members with various skill sets, can get started with the frame creation workshop by a facilitator.
10. *Follow through.* Check any assumptions, reassess research and evaluate whether the possible solutions address the original problems that were brought up. Consider how these new frames and solutions affect other areas of the business, as design problems are often interconnected and networked.

These principles help to guide the mindset of a designer when approaching a reframing exercise in order to get the most value from it. Frame creation is not a formulaic process that can be followed thoughtlessly, it requires new thinking every time (Dorst 2015:151).

Next, *futures* are examined. This is a "thinking forward" exercise that applies the frames generated in the previous step theoretically and considers what may happen as a playful exploration and envisions how things may work (Dorst 2015:78).

Once this has been concluded, *transformation* is investigated. Here the feasibility of different kinds of frames and solution directions need to be evaluated according to what would be feasible in the short as well as in the long term. This step is meant to be an exploration to unearth the implications of different ideas. Both long- and short-term ideas can be considered viable (Dorst 2015:79).

Lastly *integration* is explored. Here it is important to consider how these new frames will fit into the broader organisational context. What was learnt during the discovery can now also be integrated into the discourse in the company itself (Dorst 2015:79).

With regard to this thesis

This process introduces the concept of "reframing", which has not been encountered in other processes. It is valuable in that it encourages a completely different way of approaching problem spaces, and suggests more structured steps in order to find solutions beyond "brainstorming" or "ideation". Ideation is still important and still included in my process, but these are now guided by elements such as establishing overarching *themes*, *futures* and *paradoxes*. These aspects advance the human-centered intention of the overall process. It allows us to look at solving issues that are wicked, ill-structured, and ever-changing. These steps have been structured into a bigger, overarching process.

3.2.10 An overview of all practical processes for approaching design problem spaces

Barnes and Du Preez (2015:6) start to compile a comparison of the phases of design processes, along with the shared tools and methods for each. Their comparison only includes the IDEO human-centered field guide, along with a service design model and social design model that are not applicable for the design approaches considered in this study. Expanding on this, Table 2 compares all of the processes discussed in this chapter. As can be seen, there is a strong overlap in steps, although there are some notable exceptions that have already been mentioned in detail in the individual processes, such as the "lead in" phase from the *Live Well Collaborative Process Model,* and the detailed additional steps that Dorst's reframing provides.

Table 2: Comparison of different practical processes for approaching design problem spaces

Stanford d.school design thinking process	IDF design thinking process	Live Well Collaborative Process Model	British Design Council's double diamond approach	Google Ventures Design Sprint	The IBM Loop process	IDEO Design Kit	ISO human-centered design process	Dorst's Reframing
		1. Lead In					1. Plan the human-centered design process	
1. Empathise	1. Empathise	2. Research	1. Discover	1. Understand	1. Observe	1. Inspiration	2. Understand and specify the context of use	1. Archaeology of the problem situation
								2. Establishing the core paradox
								3. The context
								4. The field
2. Define	2. Define		2. Define	2. Define	2. Reflect		3. Specify require-ments	5. Themes
3. Ideate	3. Ideate	3. Ideation	3. Develop	3. Sketch	3. Make	2. Ideation		6. Frames
								7. Futures
								8. Transformation
		4. Refinement		4. Decide				9. Integration
4. Prototype	4. Prototype		4. Deliver	5. Prototype		3. Implementation	4. Produce designs and prototypes	
5. Test	5. Test			6. Validate				
		5. Next steps						

3.2.11 Critiques on the various processes

Every one of these processes have neat and tidy visualisations that are logical and linear. Cotsaftis (2019) states that design thinking literally aims to "think like a designer", which is a free-flowing creative practice that links up connections not previously suspected. These linear processes leave no space for abstraction and design to conceptualise the new, even though it is usually stated in the process document that accompanies them that these are iterative processes that can be followed in any order. Surely "design thinking", i.e. "thinking like a designer", is also used when designing a chair or a building, but these linear processes are not used or deemed necessary.

These types of pre-packaged toolkits appear to be a strategic move to show the value of design to non-designers such as clients, again tying into the discussion in Chapter Two on "design for business' sake". The aim seems to be to make the design process overt to non-designers (such as business owners), so they can measure where in the process designers are and how they are adding value. It can also be

used to show non-designers something of what the design process entails, possibly to contradict the tendency from clients to assume that design happens instantly and without effort. The other purpose of these types of toolkits is to teach design students and junior designers. It provides a clear guideline to follow, as they cannot rely on experience or intuition just yet - these only come with experience. However, leaving a designer (or a non-designer) with these templates to follow is not sufficient to truly engage in a "design thinking" or human-centered design process. The person doing the design work influences the definition of the problem space in the first place. Thus, if the problem is insufficiently defined, it will not matter how closely or how well these predetermined processes are followed. The solution reached will not address the actual problem, but potentially only a consequence of it, instead of the root.

Based on the previous discussion around *problem solvers* influencing the end solution, most processes do not consider *who* will be working on this project. For those that do mention multi-disciplinary teams, it is not discussed how these should be selected. Ironically, the selection of problem solvers is completely left out of the process, as it will influence the entire process.

The processes also do not consider which approach they will be situated within; participatory design, activity-centered design, lead-user design, etc. These approaches are not even mentioned. Perhaps they are considered more theoretical or academic, since there are numerous examples mentioned in Chapter Two within academic discourse of practical examples where these approaches were utilised and the projects were successful. Yet there is no mention of the approaches made in the design toolkits in Chapter Three. The approaches are generally aimed at designers working in the design industry, or even non-designers. This points more towards the issue of the maturity of the problem-solver. Novices may not even know that these approaches exist and will therefore not use them. On the other hand, a more advanced designer will be familiar with one or more of the approaches and choose to situate their work within that field as it allows for additional resources and proven tools to use. Whilst most design processes are quite versatile and could fit into any of the approaches, at no point is mention made that it should be considered. This again points to these processes being marketed towards novice designers or non-designers who may not have the maturity to truly engage in design endeavours on their own. This idea of "democratising design" is discussed in more detail later.

Another question that arises is whether design thinking really needs to be used for solving every kind of problem. Even regarding the Adventure Series discussed in the first chapter, it can be asked whether a design thinking process or human-centered design philosophy was really necessary to guide the design team towards the idea that putting cartoons on MRI rooms' walls would be soothing for children. It can be argued that it was an obvious solution. On the other hand, before that intervention, patients were not being considered at all, and by looking at how their experiences could

be improved the solution immediately became human-centered. It is not clear what type of approach - participatory design, co-design, community-based design, etc. - was used. The distinct possibility exists that we over-rely on design processes to solve problems for us.

As a lead user experience designer, I once attended an interview with a new client who was looking to hire our consulting company for design services. Halfway through the interview, I was asked by the head of the business unit whether I used design thinking in my work. I was unsure how to answer the question, and even now, years later, I still am. At the time I responded, hesitantly, that it formed the basis of what we do, which is we investigate what the problems are, define them, brainstorm ideas, and then test them so we can see whether we need more information before continuing. The phrasing of the question indicated a misunderstanding of what "design thinking" is and how it is used by designers in practice. While design thinking shows promise in theory, in practice it has, to a large extent, been co-opted by people in business as a means of "design-washing" [48] and checking corporate boxes by people who do not understand how designers work or approach finding solutions.

Nigel Cross (2010:99) notes that the term "design thinking" has become such a common concept that it is in danger of losing its meaning. By expanding it beyond the core design principles to include non-designers such as managers, medical workers and administrators to also be "design thinkers", we may be undermining the concept and intention of design thinking. Cross (2010) suggests that design thinking can be considered as a "form of intelligence", based on Gardner's (1983) view that there are multiple forms of human intelligence, including linguistic, logical-mathematical, spatial, musical, bodily-kinaesthetic, and personal. Lourens (2015:98) argues that "design intelligence" represents a unique way of approaching problems, and is thus a different kind of intelligence. By attempting to reduce this process for non-designers to be able to participate in a process, it can hinder the value that the design process presents when undertaken by experienced practitioners.

Design thinking can be a useful tool, but it has become formulaic and no longer relies on designers' intuition and guidance for the process. This goes back to the aspect of the problem solver influencing the very problem space they define. Steve Jobs, renowned founder of Apple, did not follow a linear design thinking process, but instead used intuition and listened to customers' needs. He did not rely on five steps that had to be followed meticulously (Jen 2017). A counterpoint to this would be that Steve Jobs was an "expert" in his field and to a large extent helped to define the field he worked in, therefore his experience counted a great deal. A non-designer or a junior designer cannot be expected to have

[48] "Design-washing" is a compound word building on the concepts of "whitewashing" and "greenwashing". Greenwashing is to make something appear more environmentally friendly or less environmentally damaging than it really is (Merriam Webster [sa] e). In this same sense, design-washing intends to make something appear as if it was created following thorough design processes, whereas it may only appear so on the surface by using the right terminology.

that level of intuition or insight. What is intuitive to a junior inexperienced designer or non-designer, is vastly different to what is intuitive to an experienced designer, exactly because of their background and previous experiences. It is now time to consider how to make design activities more accessible for non-designers.

3.2.12 Democratising design

Unlike fields such as medicine, engineering and architecture, there is no official governing or licensing body for design in South Africa. One needs to be a registered member of the relevant governing body to call yourself a doctor, engineer, or architect. This is not the case with design. It has long been a contentious topic about whether anyone can call themselves a designer and in fact, anyone can. It is not a legally protected profession in this sense.

With the advent of easy-to-use online design tools like Canva which features a large library of ready-to-use design templates, as well as WYSIWYG[49] website builders that require minimal or even no knowledge of coding, such as WordPress and Adobe Muse, it is easier than ever to design with no formal training. This may be more applicable to first order design[50] than to others, because communication design can seem to be very simple to the untrained eye.

Numerous process models in this chapter make specific mention of making design 'accessible' so that non-designers can perform these actions. Not all mention it, but by pairing methods with each step of a process, easy-to-use guides can be created. There are various reasons why this may be. Firstly, professional design services often come at a premium price. A senior to lead designer can cost anywhere between R800 and R1200 per hour for their services. A small or non-profit organisation may not be able to afford these costs, and may therefore attempt to perform these design tasks themselves.

Design and 'the creative process' has long been difficult to understand or engage with, especially for non-designers. By making the design process transparent, overt, and easy-to-use, it is demystified and enables non-designers the opportunity to see how it is performed. This makes it easier for them to take part, as in the case with participatory design or co-design. The entire process becomes less daunting, which is a constructive move. Participants should not feel intimidated by what they are taking part in. On the other hand, it can potentially encourage people to mistake their abstract understanding of design for deep, experiential understanding of the process and its product.

[49] What You See Is What You Get – this kind of website builder shows a visual representation of what a person is creating, instead of relying on them to code it and then render it.
[50] More information on Buchanan's different orders of designs can be found on page 75.

The risk arises when designers are completely excluded from the process. Some may argue that designers are no longer needed for these processes, as non-designers are now in possession of the processes and toolkits designers use. As a counter-argument I would say that I may be able to hold a scalpel but it would not mean that I should be allowed to operate on anyone. Thus by reducing complex design processes to accommodate non-designers, we may be setting them up for failure.

The various efforts by the d.school, Design Council, IDEO, Google, IBM and the rest to democratise design and make the design process accessible to non-designers, while well-intended, is ultimately a contentious topic, and arguably undermines the design discipline as a whole. Cross's (2010:99) earlier statement confirms this.[51] In recent years this phenomenon (known as "gatekeeping" – see below) is being discussed more and more in informal discourse on blogs and YouTube videos. Tobias van Schneider (2020), the product design lead at Spotify, believes that designers don't know what they want. On one hand they want everyone to appreciate, understand and practise design, while on the other hand they "gate-keep" and protect their trade. He makes the point that the benefit for everyone having access to design is that more people understand it. It is not too difficult to convince a company that they need a designer as part of their problem-solving process. But designers risk making themselves obsolete if 'anyone' can design. Other blog headlines that debate the topic include "Design Thinking and its democratizing [sic] power" (Urchukov 2020), "Why everyone is a designer… but shouldn't design" (Treder 2015), and "No, not 'everyone is a designer'" (Lisefski 2019).

Gerritzen and Lovink (2010) make the claim that *Everyone is a Designer In the Age of Social Media* in their book of the same name. The book is a light-hearted read, but emphasises the value of open-source design. Don Norman (NNgroup 2018) considers the democratising of design as a good thing, since there are not nearly enough designers to assist with all the problems that need solving in our world. He states that we should be empowering people in underprivileged communities: "[There are] people from all over the world who have problems, and don't realise they can solve them themselves." Norman suggests offering them toolkits and advice online to help them. The topic of gatekeeping in design is thus often discussed in informal discourse, although it is not yet as prevalent in academic discourse. Gerritzen and Lovink, and Norman, argue that everyone should be allowed to design and simply need the tools to do so. It can also be argued that by giving laymen the tools to design without proper instruction or guidance, it could result in even bigger design problems that experts will ultimately be called in to resolve. By implying "anyone can be a designer", it undermines the years of studying, research, and learning that designers go through in order to be experts in their field able to guide and facilitate others in this process.

[51] Page 101.

The problem-solver involved in a process shapes how the problem is defined and approached. Non-designers may follow the steps prescribed and will reach an outcome, but it may not be fully appropriate or truly solve the issues involved. This points to a *novice* or *beginner* problem-solver as described earlier in this chapter, as opposed to an *expert* (Dorst 2003; 2015).

As an example of a design process implemented by (mostly) non-designers, I refer to Vagal *et al*'s (2020) article on *Human-Centered Design Thinking in Radiology.* The name of the article may already spark concern. As discussed in Chapter 2 and Chapter 3, human-centered design and design thinking are quite different concepts, even if they overlap. Both can be approaches with different intentions, but conflating them as if they are the same is potentially worrisome. The two cannot simply be combined into one word or concept without risking epistemological incoherence. In the professional design industry, design practice and in non-academic discourse, "design thinking" and "human-centered design" are often used interchangeably especially in similar contexts, and therefore not separately or adequately defined. But in the context of academia, they should most certainly be treated as separate topics that influence one another.

At the time the *Human-Centered Design Thinking in Radiology* article was published, four of the seven authors (including the first author) were listed as medical doctors with the Department of Radiology, University of Cincinnati, Ohio. Two were listed as part of General Electric Healthcare, with one the Director of Collaborations and the other a senior User Experience designer. Moreover, the last was the associate dean for graduate studies and research at the University of Cincinnati's College of Design, Architecture, Art and Planning.

Consequently, of the seven authors, only two had backgrounds in design, and only one specifically in User Experience design, which is where design thinking is often used in practice. In and of itself this is not a problem as designers are often singular facilitators of the design process for groups of non-designers, as in approaches like participatory design and co-design discussed earlier. This guidance does need to be specific, and the designer needs to be comfortable and confident in facilitating the necessary methods and philosophies. As mentioned, the difference in design theory and design practice when it comes to design thinking and human-centered design, is significant.

The senior UX designer involved in the *Human-Centered Design Thinking in Radiology* project holds a BFA in Fine Art and Drawing from the University of Wisconsin Oshkosh, as well as an MFA in 3-D Computer Animation from Bournemouth University in Dorset. The intention of pointing this out is by no means to discredit the designer, but merely to point out that there is no evidence of formal education in design thinking, user experience design or design methodology – only 30 years' experience in design practice (Kemper 2021).

It is stated that the "human-centered design framework" is a "newer, complementary methodology" to the Agile or Lean performance management systems. "Agile" is a methodology that originates in the computer software development industry to aid in incremental delivery and quick turn-around times for clients (Agile Alliance 2015). "Lean Agile" is a specific subset of "Agile" and cannot be discussed on the same level. When not referring to the official methodology, "agile" has colloquially evolved in design practice to mean a methodology that allows for quick iteration and turn-around times, no matter whether it is for software or other types of design, such as physical products, services or processes. While it is not within the scope of this research paper to delve into this distinction further, but suffice to say that while human-centered design can form part of an Agile methodology, it is by no means a replacement for it, as they have substantially different aims. Agile is focussed on *delivery* and empowering teams to self-organise, while human-centered design focusses on creating experiences that are centred on the *people* the end product or service is intended to serve. The article also simply states that Agile or Lean do not adequately address the challenges faced by the modern healthcare ecosystem, without qualifying this statement as to how they are falling short or in what regard. What works well for software design is unlikely to be universally applicable in experience- or communication design.

The various phases in the Live Well Collaboration design process are explained, but none of it in terms of what the actual problem was that was addressed through the process. Three of the five outcome metrics are "number of workshops and projects, people trained in the methodology", "measuring empathy", and "measuring culture". These are quantitative approaches for a design process primarily focussed on qualitative processes and results. One can only wonder whether this was an attempt by the authors to "quantify" design, which is inherently concerned with quality more than with quantity. Time and time again, such an aim has proven to be counter-intuitive and difficult to do. Making these metrics the main measure of success of a design-driven process is unlikely to measure anything of real value.

This article was published in the *Journal of the American College of Radiology,* not in a design-related journal. With the focus being on radiology and the application of design, it is entirely likely that the design methodology was not thoroughly scrutinised, as it is not the focus of the journal. It does carry the risk that this will lead to spreading misinformation to others looking to use design thinking or human-centered design in assisting in their projects.

Overall, this article highlights several misunderstandings about design in practice as well as in theory, how design thinking and human-centered design can aid in projects, as well problems such as trying to quantitatively measure a qualitative process. It is a prime example of how trying to frame design thinking as a "clear-cut, linear" methodology can lead non-designers astray and lead to missing

important steps and areas needing attention in the process. The "democratisation of design" is not a solution but a result of a cultural process and therefore cannot be taken as indisputably correct or sensible.

While the democratisation of design is a valuable area of research, it ultimately falls outside the scope of this thesis.

3.3 Design framework for this thesis

One thing that has not been adequately discussed in any academic or informal discourse, is how all of these different parts of design theory intersect. Research tends to concentrate on a specific part of the process, such as human-centered design, design approaches, design problems, or design thinking processes. No model for combining all of these exists, which is why it has been formulated below. And, at the risk of becoming too simplified and formulaic, as has been the critique on the processes above, an attempt is made to visualise this process to make it easier to understand. Looking at radiology or indeed any design problem or design problem space through a systems approach is going to miss the human side of the situation. Human-centered design is therefore solidified as a central *intention* in the process.

At the start of any project, whether it is for a corporate or a non-profit client, there has to be an identification of the *need* or a *problem*. This can take various forms. A company can identify the need to make more revenue, and thus look to establishing a new product or service. A community can identify the need to have easier access to drinking water, and request help in this regard. Or a problem can be identified in an existing area (like a radiology working environment) that needs to be addressed. All of these start with a person identifying the problem or need.

It is important to note that the problem here is merely the starting point for an investigation. It is difficult to define a set problem at any point in the design process, as it evolves as the investigation continues. This problem may also merely be a symptom of a bigger problem that has not yet been discovered.

A combination of different frameworks and their methodologies have been used to create a new design process – seen in Figure 36. The overall visual is inspired by the British Design Council's Double Diamond approach, as the diverging and converging lines accurately convey what kind of thought process is engaged within each phase, be it exploratory ideation or the critical narrowing-down of ideas. The *lead-in* and *next steps* phases from the Live Well Collaborative Process Model have been

incorporated before and after the first three steps from the d.school and Interaction Design Foundation's Design Thinking processes.

Lastly, all the steps of Dorst's (2016) framework for reframing design problems have been slotted in where appropriate. These fit neatly into the predefined sections and help to guide the thought processes one must use at each stage. However, Dorst does not leave room for including end-users into the design process, nor for finding out what their "ideal" situation is and what their requirements are for a solution. This is a key principle of human-centered design (Maguire 2001:588) and is a vital step that is incorporated from the ISO framework as part of "next steps". Maguire's (2001) methods to support human-centered design are included into the framework under each applicable step. As per Dorst's (2015) explanation that complex problems are not static, the methods listed below may very well shift and change during the course of the project, as new requirements become apparent and new insights emerge.

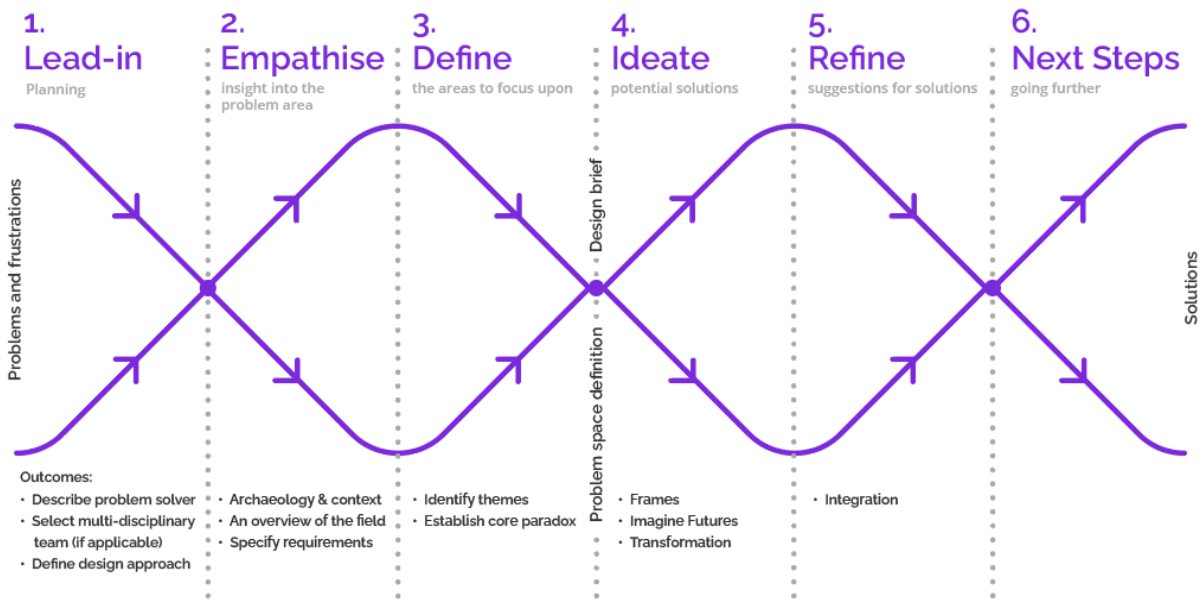

Figure 36: Design thinking reframing process. Diagram by the author, 2022.

This process is underpinned by a human-centered design philosophy, which follows the following principles as defined in Chapter Two:

1. Gain a thorough understanding.
2. Follow a people-centered approach – put people first.
3. Incorporate multidisciplinary design teams.
4. Consider the system and experience as a whole, not just isolated components.
5. Follow an iterative process.

As mentioned previously, design problem spaces do not present clear "design problems" to solve. This means that while initial problems may be identified, these will probably evolve with the development of solutions, with true design problems only being defined alongside their proposed solutions.

This design process starts with a *lead-in phase.* This phase is intended for planning – the "fuzzy front-end" of a project as Sanders and Steen (2008:7) call it. The method used is brainstorming. Expected results from this phase are firstly a *description of the problem solver.* In this phase the "problem solver", i.e. the designer or person who will be the lead undertaking the research needs to be described, in order to understand their level, background, etc. Next, if applicable, a *multi-disciplinary team needs to be selected*. If this is deemed necessary, they should be selected during the lead-in phase, at which point they should also be described concerning their problem-solving level and the skills they will be contributing to the project. Finally, the *design approach* must be defined. This process is not fixed and allows room for alterations and amendments as the lead problem solver sees fit.

The next phase is the *empathic discovery phase.* This phase is divergent, meaning that it allows for thorough investigation and research into the problem space. Methods to be used are a qualitative data collection and a literature review. Various methods of collecting qualitative data can be drawn on: interviews, focus groups, field studies and observation, contextual inquiries, diary keeping, context-of-use analyses and task analyses. Interviews facilitate the collection of in-depth information of first-hand experiences and viewpoints of participants (Turner 2010), while mixed-method research allows for a greater scope and improved analytic power of studies (Sandelowski 2000). For the literature review it is valuable to understand research that has already been conducted in the field that is being researched. Fruits of this phase are, firstly, the *archaeology of the problem situation* and *context* which involves investigating both the problem space at hand in depth, as well as previous attempts to find solutions for it. Next, an *overview of the field* is needed. This is a state that includes intellectual, cultural and social aspects beyond just the problem space. Lastly, *requirements* are specified. This includes *user and organisational* requirements that seek to understand what radiologists and registrars *want* from their "ideal" environments. As well as defining the *scope* and *objectives,* for the process, as it created criteria against which the solutions created later on can be measured. These are "stopping criteria" for measuring when appropriate solutions have been formulated.

The third phase is the *definition* phase. This is a convergent phase, meaning that the research generated in the first phase will be distilled and narrowed down. The method to be used in this phase is affinity mapping [52] which is a method for collecting and sorting through large volumes of data

[52] Affinity mapping is a method that groups large collections of data into groups or themes based on their relationships. The process can be used to combine data obtained from different mediums, such as ethnographic research, ideas from brainstorms, user opinions, user needs, insights and design issues. The exercise asks the designer to write out pieces of data such as small documented facts on separate Post-it notes, cards, or paper –

collected through interviews and brainstorms (Dam & Siang 2019). It is used to find themes expressed among the interviewees and to identify the main pain points and frustrations that were expressed, as well as any requirements and constraints. The first result of this phase is *theme identification*. When analysing themes, there is a desire for a deeper understanding of the needs, experiences and motivations of the protagonists. This is followed by the establishment of the core paradox.[53] This aids in understanding what makes the problem situation hard to solve.

The next phase is that of *ideation.* This phase is divergent, meaning it is considered a "safe space" where no ideas are bad and the aim is to generate as many ideas as possible. Critical assessment of these ideas happens in the next phase. Methods to be used are brainstorming and ideation and the aim is to generate solutions for the identified pain points and frustrations, that fit within the requirements and constraints. The first result of this phase is *frames*. This means the application of new frames to the existing problem space which is the heart and soul of what Dorst aims to achieve through his framework. It requires that one think of a current problem situation *as if* it were something else, which may lead to a different way of thinking. The next effect is *imagining futures.* **T**his is a "thinking forward" exercise. And finally, *transformation*. Here the feasibility of different kinds of frames and solution directions are evaluated.

The fifth phase is *refine*. This is a convergent phase in which the ideas that were generated in the previous phase are evaluated for suitability or feasibility using critical analysis. The lead researcher may first analyse ideas either on their own or in collaboration with their multidisciplinary team (if applicable) to sift which ideas are suitable for a wider audience. From this will come the *integration* phase. This is when it is important to consider how these new frames will fit into the broader organisational context.

The last phase of the process is *next steps,* where practical next steps are considered.

While this may seem like a linear process, a phase or previous phase may be repeated if deemed necessary, or if the understanding gained through the process of the phase changes the understanding

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one piece of data per piece of paper or card. Thereafter, each card is picked up and compared to the previous card: does it fit into the same group, or part of a different group? Slowly clusters of different relationships form, and these can then be named according to the relationship they display: pain points, opportunities, insights, etc (Dam & Siang 2022).

[53] According to Dorst's reframing steps, establishing the core paradox is the second step, after understanding the archaeology of the problem situation. It thus requires the problem-solver has a thorough understanding of the problem space before continuing, which allows them to be in a place to identify the core paradox. However, generally a problem-solver may not have a comprehensive understanding of a problem space at that point already, and will therefore require information obtained during the *Empathic discovery phase* in order to successfully establish a core paradox. This step also requires one to adopt a different mindset of no longer *exploring* and *empathising*, but *defining*. For this reason I have instead placed *Establishing the core paradox* as part of step three, the *Definition phase*.

of requirements. This process mirrors a dialectical process, namely, as solutions are created, problems may be redefined, and vice versa.

In an ideal process feedback would be obtained from registrars after each "diamond", to ensure firstly that the right problems are being addressed – the first human-centered design principle (Norman 2019). It has unfortunately not been possible to involve registrars beyond the initial interviews, due to time and availability constraints. Involving those who will be using the environment and systems in the process, follows the second human-centered design principle, which has been fulfilled by interviewing the registrars. All aspects of radiology registrars' working environments have been considered – the third human-centered design principle. Testing design solutions, which has also not been possible, follows the fourth human-centered design principle.

3.4 Conclusion

This chapter has explored design problems and design thinking, along with critically engaging with different processes to problem solving in design. The aim is to create and present a human-centered model that both synthesises and improves on what is generally accepted to be standard practices. It has addressed the second aim to develop a framework underpinned by human-centered design for a South African context, particularly radiology in public hospitals. The first objective towards this aim has been to explore and compare existing processes. The second objective is to craft a framework for this particular problem space. In order to understand problem spaces, we first looked at design problems themselves, and why specifically articulated "design problems" are much less common than one may think.

The next chapter utilises this newly created framework to conduct a case study to explore how this approach can be utilised to improve registrars' environments in public hospitals in South Africa.

PART TWO

APPLICATION

CHAPTER FOUR

A CASE STUDY

Until now this study has been dominantly theory-based. This chapter, however, explores how human-centered design can be used to improve radiology environments in public hospitals in South Africa - the third and final aim of this thesis. This is achieved by means of three objectives. The first objective is to show how the reframing design process has been applied in practice, the second is to understand the existing radiology workspace by means of interviews that are analysed and, thirdly, to formulate hypotheses of possible solutions.

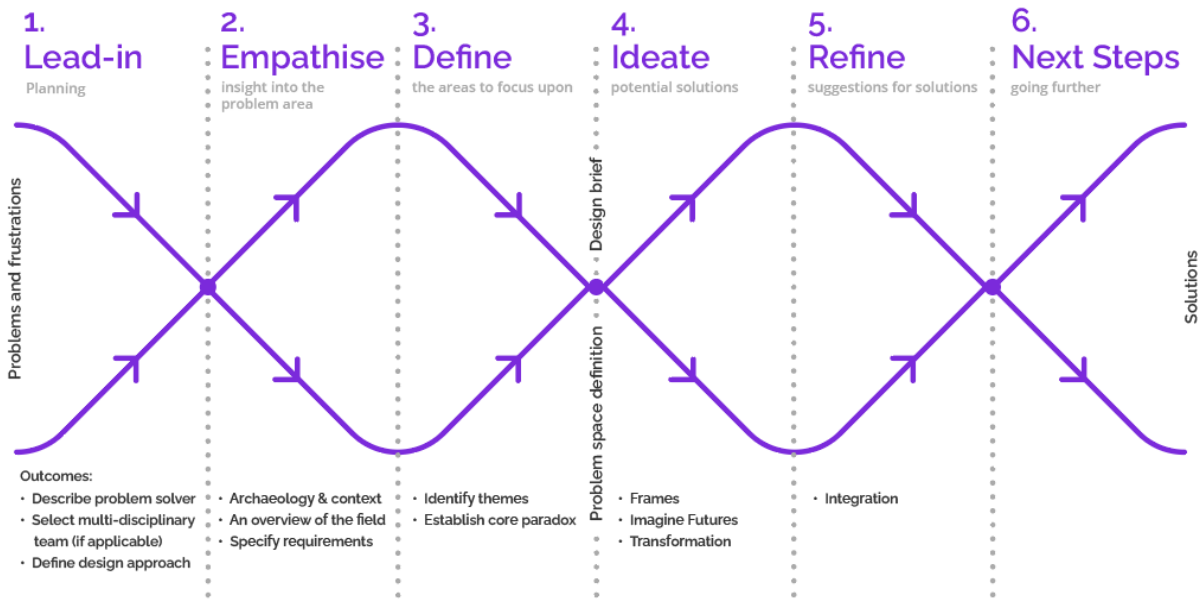

Figure 37: Design thinking reframing process. Diagram by the author, 2022.

Figure 37 shows the process that has been defined and is used for the case study component of this thesis. It must be noted that simplifying design activities to a diagram for easy interpretation does not always reflect the true design process. This is certainly the case now. While Figure 37 was defined as the final design process to be used, it was naïve of the researcher to think that this would be strictly adhered to. A major insight from following this process has been that *performing* design activities and *writing about* design activities are not synonymous.

The intention of this chapter was to follow these steps as defined, and discuss accordingly but, as the investigation proceeded, it made less and less sense to adhere to this format, as it was too linear. Instead, Figure 38 below illustrates the steps as they actually occurred in sequence. As evident, some of the steps are repeated numerous times as more content was added, and sections were rewritten and re-conceptualised. There are other ways that this diagram could be shown, such as using arrows

to indicate "going back" as can be seen in the Interaction Design Foundation's design thinking process (Figure 27, page 82).

Figure 38: Design process actually followed. Diagram by the author, 2022.

To facilitate ease of reading, steps in the design thinking reframing process have been combined occasionally, as they build upon one another in practise, and repeat similar information when separated. This chapter, therefore, at first partially follows the format of the design process where it makes sense, but breaks away from it when discussing the creation of frames and themes, as these are design activities that cannot be separated in a meaningful way, nor should they be.

4.1 Lead-in phase

This phase is intended for planning – the "fuzzy front-end" of a project as Sanders and Steen (2008:7) call it. Methods used during this phase were brainstorming and ideation.

4.1.1 Description of the problem solver

I will be tackling this problem space as an experienced information designer and researcher. I currently hold a BA in Information Design from the University of Pretoria in South Africa, as well as a Master's of the Arts also in Information Design from the same institution. I work fulltime as the Head of User Experience (UX) and User Interface (UI) Design for an international software consultancy, and I have been working in design-related industries for 12 years. I was a lead designer before taking on my current role as head of department – the most senior position a User Experience designer can hold while actively designing solutions for clients. Higher levels (such as Design Director or Head of Design)

are more managerial, involving ensuring employee happiness, liaising with clients, and working on proposals for new projects.

Looking at Dorst's (2003; 2015) levels of design expertise as discussed in Chapter Three (page 72), I fulfil the requirements for *naïve, novice* and *advanced beginner* by means of my formal training in design, which allows me to adapt design approaches based on the situation that is faced. I fulfil the requirement for a *competent* designer by means of my experience working in the design industry – I don't merely respond to situations, but help to define the problem space. I intuitively respond to design challenges, get involved in the problem space, and seek new opportunities and challenges, all of which fulfils the *expert* designer criteria. I consider myself to be beyond *master* (level six) because while I fulfil that role – I look for subtle clues in context in terms of how to improve processes and I strive to extend the domain and create new domains. The very act of writing a PhD thesis on the subject of new approaches and frameworks to design shows that I do not accept the status quo in terms of solutions offered. I challenge the norm, and work to create new domains which is a requirement on the *visionary* level. I thus rate myself at the level of a *visionary* problem-solver, i.e. the highest number on a scale of seven. Given that this is a subjective evaluation, this level is not selected lightly.

From an axiological perspective I value empathy, and I appreciate in a deep sense where healthcare professionals are coming from. The rest of this section outlines how my personal background has allowed me to empathise with healthcare practitioners. My values also tie into Buchanan's (2001) emphasis on human dignity. I am concerned with treating people respectfully and being mindful of our fellow man. For this research I take an interpretivist approach, as data was collected by means of interviews, and concerns an in-depth investigation. For this research I wear dual hats: both that of the researcher, as well as the solutioner.

Another aspect to consider apart from the researcher's skill level, is their context. Having and developing empathy for the subjects of a study is a vital aspect of human-centered design. I have a lot of empathy for doctors and those in the medical profession, since many people in my family have been, or are involved, in healthcare, as can be seen in Figure 39. Generally a family tree and personal anecdotes would have little to no place in research, but its relevance has had a big impact on my capability to empathise with healthcare workers and understand their working environment.

Figure 39: Spangenberg and Steyn family trees. Blue indicates medical doctors, while teal indicates other healthcare professionals. The author is indicated in purple, and non-healthcare-related relatives are indicated in grey. Diagram by the author, 2022.

My father is a general surgeon who specialises in trauma-related operations and gastro-intestinal surgery.[54] He has been practising as a surgeon for 35 years. My brother obtained his MBChB (UFS)-degree in 2006, and has been practising as a radiologist[55] since 2019 after specialising. My grandfather on my mother's side was a general practitioner (GP) and after retiring from private practice at the age of 60 years, was the superintendent of a 650-bed state-run hospital. My grandfather on my father's side was a radiologist, and my grandmother a nurse. I have an uncle who is a radiologist, his life partner is a general practitioner, my aunt and cousin are physiotherapists, and another aunt and uncle are dentists. Their son is a dentist as well and their daughter is a pharmacist. I also have two aunts who are nurses. The list goes on.

When I was born in 1988, my father was already a qualified general surgeon. The patients he saw ranged from emergency trauma, such as car accidents, assault, shot- and knife-stab wounds, to more general gastro-intestinal issues such as infected appendices, hernias, and bowel obstructions. For two years he was alone[56] in a private surgical practice in Welkom: the second largest city in the Free State , with a population of around 64 000 people. I saw little of him growing up for the first few years of my life because of this, although he would regularly tuck me in when he arrived home after midnight after being out on a call. He usually arrived home between 20:00 and 22:00 and would often be called out

[54] My father obtained his MBChB (UP)-degree (which qualified him as a General Practitioner – a GP) in 1976, and after specialising for 5 years, obtained his MMed (Surg)(UFS)-degree in 1987.
[55] My brother specialised for 5 years to obtain his FCRad (SA) and MMed (Radiol)(UFS)-degrees.
[56] At that time there were also two other private surgeons in Welkom with whom he shared calls at the State Hospital but who did not share calls for his private patients. He gained a partner in his practice in 1990, and a second partner in 1997. My father retired from full-time surgery at the end of 2019 – after his third heart attack – for which he later had a third triple heart bypass. He still continues to assist his former partners in operations from time to time, and is currently 69 years old.

again. My father worked an inordinate number of hours, but never once complained. My mother once mentioned that in all of the years of my father being called out in the middle of the night for an emergency, she had never once heard him complain or grumble – he simply saw it as his duty and responsibility to help people.

My mother was the practice administrator for the surgery, retiring mid-March 2020. She had a myriad of responsibilities, but overall she was responsible for the financial well-being of the practice, as well as the rest of the back-office admin and clerical staff.[57] I grew up in the surgery's offices: my mother brought me with to work every day until I started preschool at the age of 5 and since my mother often worked evenings as well to get all the paperwork done, my brother and I would either play in the children's play area, or create our own games.

People sometimes have complaints regarding doctors: waiting times in doctors' rooms, costs of consultations, costs of operations, and negligence. For my part, growing up with a deeper understanding of the humans involved in healthcare, I would always defend doctors and counter the arguments. If my father's patients were waiting for a long time to be seen in his rooms, he was either busy with an emergency consultation in the Emergency Room, tending to a patient collapsing in the ICU, or performing emergency surgery in theatre. When he knew he was called out for an emergency, he would always keep the receptionists informed and the patients were given the option to wait for him or to reschedule their appointments. Regarding costs, the South African Medical Association (SAMA) suggests a baseline rate for consultations for various doctors and specialists yearly, and most medical aids only pay that minimum. Doctors can choose to charge above and beyond that and often do, as the minimum is often not enough to cover their practices' running costs for admin staff.

The costs for an operation are largely influenced by hospital costs, and the surgeon doing the operation only receives a fraction of the fees. The surgeon also includes a fee for the Assisting Doctor in his account which is then paid to the Assistant. The Anaesthetist renders their own account. The hospital account includes the ward fees per day as well as separate theatre fees (per minute), oxygen and anaesthetic gas (per minute), fees for theatre stock, ward stock, medication and nursing staff. For instance, prosthetic blood vessels – to replace a length of artery that was damaged or severed during a car accident – are sold in 60cm lengths in sterilised packages, and cost approximately R13 000 to R21 000 each (Healthcare Professional 1 2022). Once opened, the material cannot be used for any other

[57] She did the coding of all the surgeons' daily scheduled theatre lists, their after-hours/emergency consultations and procedures, ICU and hospital revisits, as well as the daily submitting of all the accounts to the medical aids and private patients (patients who don't belong to a medical aid). Furthermore, she printed the Medical Aid Statements received via email every day and correlated it with the banking statements and wrote out the receipts. She also dealt with queries to the Medical Aids regarding non-payment issues. She handled the payroll of the staff, payments to the Assisting Doctors, all creditors, did the daily banking, collected the post from the Post Office, bought the groceries for the practice. She was also responsible for the design and updating of the various forms and monthly On Call Roster sent out to the various hospitals and Hospital wards.

operation or patient, even if only a short segment was used for a particular surgery. Then after surgery aftercare is required: a hospital stay in a ward with nurses looking after you 24 hours of the day, medication issued and food. As an example, in 2022 the cost for an uncomplicated appendectomy (the operation to remove your appendix) could be R30 000, but the surgeon's total fee would only amount to roughly R4 000, including aftercare and follow-up postoperatively at the rooms (Healthcare Professional 1 2022).

Lastly, the subject of negligence by doctors. My parents always sought not to involve us in medicolegal issues involving patients. I never realised until I was older that my father sometimes had to testify in court. He was mostly called in as an expert witness, but sometimes also to defend against negligence accusations against colleagues. These cases were mostly brought by patients who had been in an accident or trauma and had had extensive, very expensive surgeries and prolonged hospital stays, leaving them with large medical bills and associated loss of income. Suing the doctor for malpractice is often a last resort to try and recover some sort of costs.

Growing up surrounded by medical professionals, seeing the hours my father worked and the sometimes misplaced perceptions of people about certain aspects of healthcare, ensured that I have always seen healthcare professionals as people first and foremost. It is the reason why I undertook this specific project. There was too little emphasis placed on improving healthcare professionals' working environments. As discussed later in point 4.1.3, this empathy for doctors does not risk this study becoming subjective, but instead forms the very basis for the academic approach used, namely, empathic design.

4.1.2 Selection of multi-disciplinary team (if applicable)

The nature of this study placed restrictions on how the design research could be conducted. It is a solo "project" initiated and undertaken by myself, with no budget to add additional members to the team. Its focus on scholarly research is also slightly different from the focus of a standard design project. Because of this, a multi-disciplinary team was not assembled to conduct the research. However, I carefully selected my research supervisor for this process, as well as the diagnostic radiology department with which I collaborated for my research.

The diagnostic radiology department at the University of the Free State was selected as I was able to secure an introduction to the Head of the Department, Professor Janse van Rensburg, who was willing to let his team participate in my research. He had been my brother's supervisor for his research as a registrar. The registrar who coordinated my contact with the other registrars had been a few years behind my brother, and I had met them on occasion when I visited the Universitas radiology

department in 2019, as I started writing my proposal for this thesis. Three of the registrars who I interviewed asked me afterwards whether I was Ben's little sister: I never mentioned it, but our surname is relatively unique. They remembered him – they were first or second year when he was in final year – and were intrigued that my research included their department. When my brother heard I had been interviewing some registrars that had studied with him, he immediately stood up and phoned them to catch up. Three years after working together (my brother finished at the department in 2019) they still shared a closeness. This sense of community and camaraderie between registrars is one of the main themes that was uncovered as part of my research, and is elaborated on later in this chapter.

4.1.3 Define design approach

As discussed in Chapter Two, there are various human-centered design approaches that were considered for this project. Due to time constraints as well as limited time available from registrars themselves, more *user-led* approaches such as participatory design, co-design or a lead-user approach were not deemed appropriate, as these require a large time investment from the subjects. Methods that were initially considered, such as contextual inquiry, diary keeping and workshops, were abandoned later on. The diary-keeping requirement was actually included in the *Letter of Informed Consent* that was sent out to registrars and radiologists, but later deemed too intensive, and thus abandoned in January 2022.[58] Upon seeing the requirement in the document in April 2022, Radiologist 2 (2002) expressed concern and asked if they really had to record their actions and frustrations for 2 weeks, as it would impact their daily working considerably and require a lot of time. This reinforced and validated the decision to remove this requirement, as it is never ideal for a subject to start engaging in research when frustrated.

In the end two approaches that are more *design-led* were utilised. These were an ethnographical approach in terms of evaluating what the situation *currently is*, as well as an empathic design approach in terms of what it *could be*.

To recapitulate, ethnography seeks to understand the current practices and experiences of people, as well as the way they use products or systems. The four founding principles (Blomberg *et al* 2002) were achieved in the follow ways:

1. **Consider people in their natural settings**
   While observation was not possible due to restrictions imposed by the University of the Free State – studies were to be conducted remotely as far as possible due to the ongoing Covid-19

[58] The change in methodology is discussed in more detail on page 35.

pandemic. I did manage to interview registrars about their environments, their daily habits, experiences, pain points, frustrations, and areas of importance to them. I was also able to visit the Universitas Academic Hospital's diagnostic radiology department in 2019, where a radiologist showed me the department, and was able to talk me through their work processes and show me their working environment.

2. **Look at a holistic view of the problem space**

   Above and beyond the interviews with the registrars, care was taken to understand the environment of radiology in general, as well as the archaeology of the problem space (as part of 4.2 in the next section)

3. **Be descriptive in accounting for the everyday activities happening in the current problem space.**

   By having informal, semi-structured interviews[59] with the registrars, they were encouraged to describe and discuss their environment in their own words.

4. **Take the subject's view into consideration: the language they use, how they categorise their space, etc.**

   As per point 3, by having informal, semi-structured interviews with the registrars, they were encouraged to describe and discuss their environment in their own words, which were in turn used to categorise frustrations, pain points and opportunities.

Empathic design on the other hand seeks to not only understand an existing environment, but also to gain an understanding of how people experience their current environment, the people in it, and including the subjects as key characters in their everyday lives (Koskinen *et al* 2003). The five-step process for an empathic design approach (Leonard & Rayport 1997:108-113) fits neatly into the design thinking reframing process that has been defined for this project:

1. **Observation**

   As discussed earlier, observation was not possible, but insights were gathered by interviewing registrars.

2. **Capturing Data**

   This occurs during Phase two: the empathise/discovery phase.

3. **Reflection and Analysis**

   This occurs during Phase three: the definition phase.

4. **Brainstorming for solutions**

   This occurs during Phase four: the ideation phase.

[59] Semi-structured interviews were conducted as this allowed for a more fluid way of asking questions: allowing new ideas to be introduced and the conversation to flow naturally (Knott, Rao, Summers & Teeger 2022).

5. **Developing prototypes of possible solutions**

   This would occur during Phase five: the refine phase. The scope of this project does not include creating prototypes of possible solutions, only suggestions for possible solutions.

4.2 Empathic discovery phase

This phase is divergent as it allows for thorough investigation and research into the problem space.

Two different methods were used for this phase, namely, a literature review, as well as one-on-one interviews with registrars as well as radiologists. A thorough literature review on the emergence of human-centered design, human-centered design approaches and their applications in a South African context, as well design thinking processes, have been conducted in Chapters One, Two and Three.

Because observation was not possible due to restrictions imposed by the University of the Free State's ethical approval process[60] – studies were to be conducted remotely as far as possible due to the ongoing Covid-19 pandemic – I interviewed registrars about their environments, their daily habits, their experiences, pain points, frustrations, and areas of importance to them. The path to actually being able to interview the registrars was lengthy – it took more than a year – and pointed towards how busy their schedules are.

My first communication with Professor Janse van Rensburg, the head of diagnostic radiology at UFS, about my research study occurred in May 2020. Application for ethical clearance to allow me to interview registrars and consultants at UFS was first submitted in August 2020. A revision on the application was required, and approval was granted in April 2021. At this time I contacted Professor Janse van Rensburg to enquire about possible interview dates, who advised that half of their team were writing exams in mid-May, and would not be available or willing to be interviewed until after they were finished.

At the end of May 2021 I enquired whether the registrars would be available for interviews yet, and Professor Janse van Rensburg forwarded my letter of informed consent to one of the registrars (who facilitated my eventual engagement) to distribute to the rest of the registrars. I followed up in June 2021 as I had had no response, and was asked to please wait a bit since they had challenges with registrars leaving, others writing exams, as well as dealing with the third wave of Covid-19. I was informed that they would have 5 new registrars starting in August, and that the Covid-19 wave would hopefully have died down by then.

[60] Discussed in more detail on page 35.

I sent an email to my supervisor, Prof Reyburn, on 15 June 2021 expressing concern that I might not be able to complete my case study in time for my intended hand-in date in August 2021. I was also not able to conduct my interviews with radiologists in private practice due to the third wave of Covid-19. One radiologist noted that they had been on call for 10 days during which time they had not been home, barely slept, and had had a minimum of one patient dying a day. Their fellow radiologist had Covid-19, and they were thus the only radiologist available during that time. They did not have the mental or physical capacity to talk about their working environment. In June of 2021, my supervisor emailed the deputy dean at the University of Pretoria to explain the situation and ask for advice, as initially the aim was to complete the study by the end of 2021. However, the Covid-19 situation persisted and this was not possible. My supervisor and I therefore agreed that we would not add pressure to our already overworked healthcare workers, and I would delay my interviews for a few months even though this meant the inevitability of handing in my final thesis later than planned.

I sent a follow-up email to Professor Janse van Rensburg and the registrar at the end of September 2021, and received an automatic out of office response, saying that they were on leave and would be returning on 11 October 2021. I mailed Professor Janse van Rensburg and the registrar who was assisting me in January 2022 to follow up on interview dates. The registrar who was facilitating my introduction with the other registrars proceeded to send the letter of informed consent for my study per email to the other registrars again, and ask who would *not* like to be included in my study – an opt-out strategy that I was only informed of afterwards. Nobody indicated that they would like to opt out, and I was sent a pdf document that listed the names and contact details for eight registrars at the department as of January 2022, as well as two radiologists that would be qualifying and finishing their degrees by the end of January 2022.

After receiving the list of their details, I sent out an introductory email to all of the registrars and the two radiologists, encouraging them to book an interview at a time suitable for them via Calendly: an online meeting-scheduling platform that allows the organiser to set available times and dates, and subjects can choose a meeting slot as suits them. After sending out a second reminder, six registrars and one of the recently-graduated radiologists scheduled interviews. Of the seven interviews conducted, five chose to schedule interviews after hours, i.e. after 5pm or over weekends.

The interviews were conducted virtually via video conferencing between January and March 2022. Zoom is an online video conferencing program that allowed me to talk to the subjects “face to face” as it were. Interviews lasted between 30 and 90 minutes, depending on how much registrars wanted to discuss. Questions that were asked include, “What does your typical day look like?”, “What do you like about your working environment?” and “What is your biggest frustration at work?”[61] Of the

[61] The full interview schedule can be found under Annexure C.

interviewees two were in their first year, two were fourth year, two were fifth or final year, and one had recently qualified as a radiologist at the end of January 2022.

Four radiologists in private practice were also contacted and asked if they would be willing to participate in the study, with the intention of using private practice as a 'best case' scenario where ideas for improvements and/or solutions could be gleaned from as they have much more control over their workspaces. Of the four, one declined outright, stating that as they were the most senior member of their practice they were much more involved in the administrative aspects of the practice, didn't participate in the day-to-day workings or reporting on scans any more, and did not believe they would be able to add value to my study. They referred me to another radiologist in their practice who I contacted in February 2022. They stated that they were very busy but would try to make time for the interview. They were unfortunately unable to commit to a time to be interviewed. The third radiologist I first contacted in June 2021, at which point they indicated that they would be happy to participate in my study. However, as mentioned earlier, it was in the middle of the third wave of Covid-19. This meant they were scanning Covid-19-positive patients daily and they had been on call for 10 days with at least one patient dying daily. Consequently, and understandably, they did not have the mental or physical capacity to talk about their work. I followed up with them periodically from February 2022, and we were able to finally conduct the interview towards the end of May 2022. The fourth radiologist also indicated that they were willing to be interviewed, but were unsure when they would have time. After checking in periodically from January 2021, the interview was eventually able to take place in April 2022. Even though it took a long period of time to be able to interview the radiologists and registrars, this in itself gave me an insight into their working life – how busy and chaotic it generally is.

4.2.1 Archaeology of the problem situation and context

This involves investigating the problem space at hand in depth as well as previous attempts to find solutions for it.

Designers generally operate in *problem spaces*, as opposed to dealing with specific defined problems. The department of diagnostic radiology at the University of the Free State is indeed a problem space that consists of ill-structured problems, as well as various *wicked problems*, as defined by Rittel (1922) on page 74. This section merely seeks to introduce the background to some of the complexities at play in the department – they are explored in depth later in the chapter when registrars' interviews are analysed and themes emerge.

The department of diagnostic radiology at the University of the Free State has undergone a number of changes in the past few years, some of it causing instability. Several of the registrars interviewed referred to these changes in passing and, in order to fully understand the context, it is important to

explore this. This is not intended to be a full record of events that occurred, and some have been omitted for the sake of brevity. The intention here is to explain some of the resulting consequences of these complex situations that registrars are still experiencing years later.

Professor Coert de Vries, a radiologist who qualified in 1998, was appointed as Professor, Chief Specialist and Head of Department Clinical Imaging Sciences (Radiology) at the University of the Free State in 1999 (Inside Radiology [sa]). He held this position until 2017. In 2016 Prof De Vries and Associates brought an application against the MEC: Department of Health regarding "alleged harassment of or interference with the practice of the radiologists by officials of the Department" (Daffue 2017). This application was heard in the High Court of South Africa and on 2 March 2017 Judge JP Daffue ruled in favour of the applicant. In other words, Prof De Vries and Associates won. This application was an interdict that allowed the radiologists to continue to perform their duties, until such time as the bigger case that was ongoing could be resolved.

The bigger situation is complicated and will not be delved into in too much detail for the purposes of this thesis. In a nutshell: radiologists working in public practice are allowed to rent radiology machinery from the State and run a private practice after hours (i.e. after 4pm) with a valid contract in place. However, in mid 2016 the MEC: Department of Health declared the contract void, and requested that radiologists cease their private practice. When they did not, security officers confiscated files and computers related to the private practice, removed radiologists from the premises and changed the locks to their offices. Dr BAF Benganga, the MEC: Department of Health, also physically prohibited Prof De Vries from entering an operating room where he had a patient waiting. In their ruling Judge Daffue (2017) refers to the MEC of Health's actions on the morning of 29 July 2016, "… like a bull in a China shop…". The registrars working at the department at the time saw and experienced this unrest in the department, and some were part of the forced evacuation of the rooms. Some of these registrars are still at the department, and formed part of the subjects interviewed.

In July 2017 Prof de Vries resigned from his position both as Head Radiologist at the Department of Health, as well as Head of the Department of Diagnostic Radiology in the Medical Faculty at the University of the Free State with immediate effect . In his resignation letter he states that he was wilfully sabotaged and intimidated which made it difficult to perform his professional duties and responsibilities (Netwerk24 2017, translation from Afrikaans by the author). After his resignation, the remaining radiology consultants took turns as 'acting head of department', until Professor Jacques Janse van Rensburg was appointed as Associate Professor and Head of Department in 2020.

This instability between 2016 and 2020 had a number of consequences on the department, which is in turn reflected in the themes that emerge under registrars' current frustrations, and discussed in detail

under those findings later in this chapter. In terms of practical effects at the time: in 2013 there were nine radiology consultants at the Department of Diagnostic Radiology at the University of the Free State. By mid 2019, there were only two (Healthcare Professional 1 2022). While it is not known for certain what their reasons for leaving were, it is possible that they faced the same frustrations as Prof De Vries or that they left *because* he resigned. It is also possible that the consultants leaving the department had no correlation to Prof de Vries.

Nonetheless, the significance of this decline in consultants directly relates to the registrars in the department. According to Health Professions Council of South Africa (HPCSA) guidelines, every consultant is only allowed to oversee four registrars, to ensure they have adequate supervision while learning (Radiologist 1 2022). Because of the decline in consultants, by mid 2016 the department would only have been allowed eight registrars (overseen by two consultants), whereas in 2013 this number would have been 36 (overseen by nine consultants).

The workload in a hospital stays the same, regardless of the number of staff. This decrease in numbers resulted in an influx of work, as well as a feeling that their academics were "on the down low", according to Registrar 1, while Registrar 4 feels that the focus is " … more about service delivery than academics at this point…". More insights gleaned from registrars are discussed later in this chapter.

4.2.2 An overview of the field

By exploring an overview of the field we look at a space that includes intellectual, cultural and social aspects beyond just the problem space. The problem space that has been investigated is the diagnostic radiology department at Universitas Academic Hospital in Bloemfontein. This department forms part of the University of the Free State, since Universitas is a teaching hospital. Working there are medical students, medical officers, consultants, professors, as well as registrars that are busy specialising in certain areas of medicine for their master's degrees: such as surgery, emergency medicine, and our focus: diagnostic radiology.[62]

In South Africa there are two types of hospitals that form part of the healthcare system: public, and private. Public hospitals are government-funded, and any citizen of South Africa can receive healthcare there. Private hospitals generally require the patient to belong to a medical aid or health insurance scheme that is privately administered and paid for. Public healthcare – where patient payment operates on a payment scale depending on the income of the patient – has many potential

[62] As a reminder from Chapter One: radiology is a specialised field within medical science that aims to diagnose diseases by obtaining and interpreting medical images of patients. There are various ways that these images can be obtained, ranging from using X-rays, to the administering of radioactive substances, to sound waves, to using the body's natural magnetism (Radiological Society of South Africa [sa]).

disadvantages such as long wait times, older facilities, and poor disease control and prevention practices (Young 2016). Whereas private healthcare offers shorter wait times, more modern facilities, appointments that are not rushed, and proper disease control and prevention practices.

Universitas Hospital in Bloemfontein is partly a private hospital run by Netcare, and partly an Academic teaching hospital that is government-funded and part of the University of the Free State's Faculty of Medicine. It is one of two hospitals within the Netcare Group that is in a public private partnership with the Free State Department of Health (Netcare [sa]).

This thesis specifically focusses on the working environment of radiology registrars at Universitas Academic Hospital in Bloemfontein. However, radiology registrars at the University of the Free State do not only work at that one hospital, they also rotate to work at Pelonomi Tertiary/Regional Hospital, which is also a state-run hospital in Bloemfontein. Registrars may also be asked to review scans from other hospitals, such as Bongani Hospital in Welkom. In the past registrars have also been asked to look at scans and x-rays from hospitals in Bethlehem and Kimberly.

One of the major differentiators between radiology in public hospitals and in private practice centres around the way the practice is structured, specifically regarding funding. In public hospitals all funding for the department, including salaries and equipment, comes from the Department of Health in South Africa. The radiology department may have minimal input into the equipment or software that is used, as well as the service plans for equipment.

In private practice, the equipment is owned by partners in the radiology practice themselves, and they provide a service to the hospital where they are located. There are two "kinds" of radiologists in most private practices: assistants, and partners. Both are fully qualified radiologists, but partners are "shareholders" in the business, whereas assistants are employees. Assistants can "buy into" the practice after a set amount of time that differs from practice to practice: this can vary between six months and three and a half years, or even longer (Radiologist 1 2022). The reason for this "waiting period" is to allow both the assistant radiologists and partners to evaluate one another and decide if they want to work together long-term. It is essentially equivalent to a "trial" or "probation" period. This is because the amount required to buy into the practice can be quite substantial, and can be paid once-off, or be a longer-term commitment where a set amount is deducted from their monthly salary over a period of time.

Assistant radiologists receive a set salary per month regardless of the amount of patients seen, and carry no risk regarding the practice. Partners are responsible for the costs of running the practice such as salaries for assistant radiologists, radiographers, administrative staff, rent for the office space,

payment for telephone accounts, as well as the maintenance of radiology machines, and buying new machines. After all of that is deducted, partners split the remaining money as their monthly salaries. They carry the risks regarding the practice, and also share in the rewards if the practice is doing well. They thus have a vested interest in the well-being of the practice.

The reason why radiologists generally join an existing practice as opposed to starting their own, is because of how prohibitively expensive the equipment needed for a radiology practice is. According to Radiologist 1 (2022) opening a practice with entry-level MRI, CT, X-ray and sonar machines would have cost roughly R18 million in 2019. This would include a 1.5 Tesla MRI machine. A 3 Tesla[63] MRI machine alone – which is currently used at Universitas Academic Hospital – costs roughly R20 million. Banks are loath to loan that amount of money to a radiologist who is just starting out, and has no experience running a practice. It is therefore easier and more practical for radiologists that want to enter into private practice to join an existing practice.

4.2.3 Specifying requirements

The previous two sections serve as a general overview and provide some history surrounding the diagnostic radiology department at Universitas Academic Hospital in Bloemfontein, as well as an overview of radiology as a practice within public and private sectors. This section now seeks to understand what radiologists and registrars *want* from their environments; their 'ideal' environments. As well as defining the *scope* and *objectives* that are to be met.

In this instance this project was initiated by the researcher, and not by the radiology department itself or another entity looking to improve doctors' experience of their workspaces. There were thus no external organisational requirements imposed on the project. Through speaking to the registrars and the Professor in charge of the department there were also no requirements or constraints raised, although this was also not specifically discussed. I imagine that if this project *had* been initiated by the radiology department or even the Department of Health, the constraints on this project and the possibilities for solutions may have been very different. This holds true for the constraints discussed below. Requirements imposed by the researcher were that solutions need to look at improving the environment for the people involved in the process – in this case the registrars. Their lives need to be made 'easier' or 'better' in some sense. This is a very subjective requirement, and care is taken to look at the specifics of frustrations in their environment, and alleviating that in some sense.

[63] The strength of an MRI machine is measured in Tesla. 'Tesla' is the unit that magnetic strength is measured in: one Tesla is approximately 30 000 times more than the average gravity on the surface of the earth (Oryon 2019). A 3 Tesla machine thus has twice the strength of a 1.5 Tesla machine. This allows for greater signal to be collected from the human body during the scanning process – resulting in more detailed images, and faster scanning times. There are specific instances in which a 1.5 Tesla MRI might be indicated for a patient instead though, such as if the patient has implants that cannot withstand the higher magnetic forces of a 3 Tesla.

Constraints that the researcher can determine are firstly costs. Owing to the nature of the environment the department is in (it is run by a government branch, the Department of Health) – funding has shown to already be an issue. Therefore suggested solutions cannot be expensive, or difficult to implement. Radiologist workspaces are also generally carefully considered and curated, and solutions cannot disrupt their general workflow. There *are* elements that have not been carefully considered and can be altered. This chapter seeks to find those interventions.

There are a number of solutions that current and previous registrars, consultants and heads of department have already taken the time to implement, generally with their own money. These are discussed in more detail under *Themes* on page 128. The radiology department and its members are thus not resistant to change but in fact embrace it when it can make their lives and environment easier and better in some way.

The *scope* to be considered for this case study concerns the radiology registrars in the department of diagnostic radiology at Universitas Academic Hospital in Bloemfontein. Their experiences and environments are considered. The *objective* for this research is to always place humans at the centre of the process, and look to enhance their experiences.

4.3 Definition phase

This is a convergent phase, meaning that the research that was generated in the first phase has been distilled and narrowed down. At this point, it is important to ensure that the different players in this arena are noted, such as the difference between “radiologists”, “registrars”, and “consultants”, along with their different workflows. Below the summary presented in Chapter One is restated[64]:

- *Radiologists* are physicians who, after obtaining their medical degrees, have gone on to specialise in the field of radiology for another four or five years to interpret X-rays and scans (Radiological Society of South Africa [sa]).
- *Radiology registrars* are physicians enrolled in a four or five-year programme at a university to become consultants in radiology: also known as radiologists.
- *Consultants* are physicians who have already completed their specialisation degree, and continue to work at academic institutions in their speciality.
- *Radiographers* form part of the diagnostic team by interacting with patients and explaining procedures to them, operating the machinery and positioning patients on it, as well as producing the X-rays and scans that radiologists use to make diagnoses.

[64] Full descriptions of the actors can be found on page 1.

- *Physicians* or *clinicians,* in this context, refers to doctors working outside of the radiology department.
- *Patients*, in this context, refers to the persons that have been referred by physicians to undergo X-rays or scans.

Affinity Mapping

The main method that was used for this phase is affinity mapping which is a method for collecting and sorting through large volumes of data collected through interviews and brainstorms (Dam & Siang 2019). It has been used to find themes expressed among the interviewees, and to identify the main pain points and frustrations that were expressed, as well as any requirements and constraints. Affinity mapping was conducted on an online platform that acts as a virtual whiteboard, with cards that emulate "sticky notes" for ease of jotting down and moving ideas around.

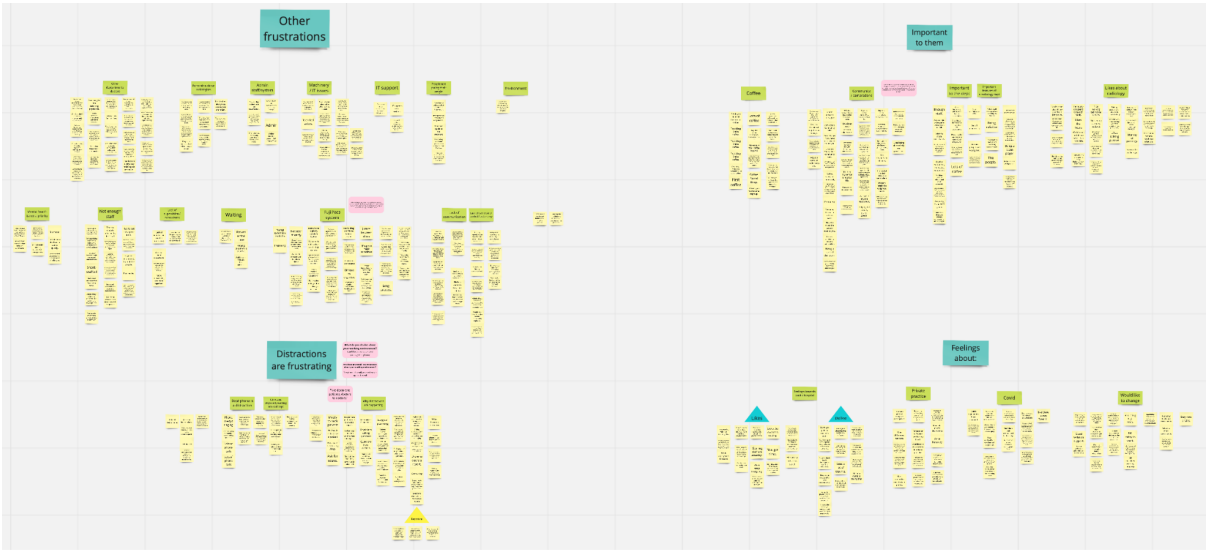

Figure 40: Affinity mapping of registrar interviews, 2022. Screenshot by author.

The seven registrar interviews were sorted in this method, and the end result of the groupings can be seen in Figure 40. The detailed findings are discussed below in section 4.3.1. Figure 41 shows a close-up of one of the sections in the affinity mapping board, and how the sticky notes were grouped together from different registrars to form themes.

Figure 41: Close-up of affinity mapping of registrar interviews, 2022. Screenshot by author.

4.3.1 Identifying themes

In analysing themes, there is a desire for a deeper understanding of the needs, experiences and motivations of the principle players. The theme analysis ends with an understanding of the universal themes relevant to the problem situation (Dorst 2015). This section addresses the second objective of this chapter, which is to develop an understanding of the existing radiology experience.

The registrars are not named in this study and have been kept anonymous to avoid any unease to them which could arise from discussing the environment in which they work. This allowed them to speak freely, without worrying about any potential negative consequences from airing frustrations and inconveniences.

All insights discussed in this section arise from the interviews with the registrars unless stated otherwise. For the purposes for this research, the one recently-qualified radiologist has also been given a pseudonym as a registrar, as it is their experiences as a registrar that this study is interested in, and also as to not single them out and potentially identify them.

Contributions from the hospital administration and other departments within the hospital have not been obtained, therefore bear in mind that these insights are *subjective* and borne from registrars' experiences. These are not necessarily representative of the entirety of a situation or all facets of it.

The three overarching themes[65] that arise from the interviews are (1) frustrations arising from interruptions and distractions, (2) perceived lack of understanding and respect for radiology, and (3) the importance of community to a radiology working environment.

- **Frustrations arising from interruptions and distractions**

The biggest frustrations that are identified by all seven registrars are *interruptions* and *distractions*. Radiologists and registrars spend most of their time reporting on the scans and x-rays they view electronically on specialised radiology workstations. Figure 41 shows two of the workspaces[66] registrars at Universitas hospital use to view MRI and CAT scans.

Figure 42: Two radiology workspaces at Universitas Academic Hospital, Bloemfontein, 2019. Photograph by the author.[67]

Interruptions and distractions break their concentration and disrupt their stream of thought, which can cause them to take longer to report. Registrar 4 explains that your work time at least doubles: "... a scan that would have taken you maybe 30 minutes now it takes you one and a half hour[s] because you constantly keep on going through [it] … again and again because the phone rings; you can't finish …" Distractions can also lead to radiologists missing out on important details. As Registrar 7 reports, "the interruptions become a problem because you forget exactly where you were in your process and what

[65] These themes were arrived at by means of in-depth affinity mapping of the interviews conducted. The method explained in more detail on page 127.
[66] Specialised medical-grade screens are used to view radiology scans and x-rays: the upright diagnostic screens pictured second and third to the left can display at a resolution of 3 megapixels, and cost around R30 000 each. While regular computer monitors can have much higher pixel ratios such as 4K or 8K – what makes medical displays unique is the grayscale rendering, as well as x and y axis positioning. Consumer displays are limited to 265 (8 bit), while medical displays offer up to 4096 (12 bit) different shades of grey. Regarding the axes: on LCD monitors off-axis distortions can occur (when an image is not viewed head-on), whereas on diagnostic monitors are far less likely to occur (Indrajit & Verma 2009). As Radiologist 1 (2022) states: on a diagnostic monitor "x" is where "x" should be, and "y" is where "y" should be.
[67] This photo was taken as part of a preliminary investigation into the radiology environment at Universitas Academic Hospital.

you've written in your report." Registrar 4 adds that when you are interrupted "you completely forget where you were with that scan, how far you were, what you wanted to say still, but [that] you haven't [included]."

The two biggest interruptions and distractions that registrars face are (1) phone calls on the department's landline, and (2) physicians walking into the radiology department who want to talk to them. Registrar 4 notes that they wish they could "lock the door and plug out the phone", while another mentions that they feel more interrupted now than they were as a trauma surgeon. Four registrars mention that the phone is "always" or "constantly" ringing. Registrar 1 discusses the importance of a space where you can work without being interrupted, and continues that, "… you need to be available for the clinical team, but it is often very frustrating when you are busy focussing and concentrating on something and then you have to stop to speak to a doctor or someone who comes in to ask something. I think that's probably my biggest frustration." Registrar 3 mentions the importance of always having paper nearby in case the phone rings and you have to note things down. When asked about small inconveniences in their working environment, Registrar 3 gleefully mentions that the phone is small; it can be broken against the wall.

There are several reasons why physicians are contacting the radiology department, and have been summarised below:

1. Mostly physicians want to book a patient or ask for scans
2. Physicians may have questions regarding a report that they have received
3. Physicians may ask for advice regarding scans that they would like to have done, i.e. whether an MRI or a CAT scan would be recommended, for instance
4. A consultation may be required for surgical planning – vascular surgery and orthopaedic surgery were specifically mentioned
5. Emergencies: physicians will let the registrars know to prioritise a report
6. Physicians will call to confirm what "list" a patient needs to be placed on, e.g. elective, PRN (Latin for Pro Re Nata, meaning "as required"), or an emergency list
7. Transfers. Patients may need scans in order to be transferred between clinics or between Pelonomi and Universitas
8. Radiographers may have questions
9. Physicians may want to know why waiting times are very long (for instance the waiting time for a mammogram is currently 2 years)
10. Phone calls to the radiology department need to be made from a landline, therefore some physicians find it easier to just walk to the department
11. Physicians may want to debate a report that they have received, or think that the report is incorrect

12. Physicians may ask questions that they could have looked up themselves, or ask registrars to measure something on a scan that they could have measured themselves
13. Physicians may want to receive a verbal report directly from registrars – many physicians have become accustomed to this
14. Bongani hospital (a state-run hospital outside of Welkom that has radiology equipment but does not employ radiologists) may call to ask how to scan a patient
15. Physicians may ask the same questions as their colleagues within the same department. This points to a lack of internal communication within that department

When asked why these distractions and interruptions were occurring, two thoughts came to the forefront. Firstly Registrar 2 makes the point that "[Radiologists] are not doctors to patients. We are doctors to doctors." I.e. the reports they write are not meant for patients, but for referring physicians to consult in order to better treat their patients regarding diagnoses and treatments. And secondly, Universitas is a training institution, so doctors ask questions of each other as they learn.

It is worth noting that medical students and interns from other departments are not allowed to request scans from the radiology department, only registrars and consultants from those departments. This is to reduce the chances of incorrect scans being requested or incorrect instructions being relayed.

Unfortunately these disruptions and interruptions are not limited to the registrar experience or even public hospitals. Radiologist 1 notes that even in private practice interruptions by referring physicians is still a regular occurrence and their biggest dislike about their environment. Their way of dealing with it is to tell the physician to please wait until they are finished, and then return their focus to writing their report and interpreting scans, which is like "…solving a puzzle, or playing a game of chess". Radiologist 2 (2022) states that interruptions are part of being a radiologist. In their private practice there are a lot of mechanisms already in place to reduce interruptions to the bare minimum, but, " … they keep coming." They once counted 13 interruptions in less than 30 minutes while they were trying to report on an MRI scan. In their hospital physicians stand behind them and wait until the radiologists are available to talk, but it annoys Radiologist 2 too much, so they immediately attend to the physician. They once asked that physicians do not enter the radiology back office (where the radiologists sit) at all, but this only lasted 3 days.

Interruptions can influence one's personal state, specifically as relates to negative emotions such as irritation or frustration (Mandler 1975). This is clear from the feedback registrars give regarding how they feel about interruptions. The impact of distractions on radiologists is also well-documented in academic literature. Balint *et al* (2014) report an adverse effect of telephone calls on on-call radiology

residents' [68] accuracy: one additional phone call during the hour before a report is written resulted in a 12% increased likelihood of resident error. Yu *et al* (2013) write on how interruptions in radiology workspaces – specifically telephone calls and other modes of physician-to-physician communication – impact radiologists. Schemmel *et al* (2016:1210-1211) separate radiology workflows into image-interpretive tasks (IITs) and nonimage-interpretive tasks (NITs). They elaborate that that IITs are tasks such as image interpretation, reporting and report editing, while NITs entails phone calls, in-room consultations with physicians, other radiologists, and radiographers, teaching, protocoling, out-of-room time for procedures and meetings and personal time. Lee *et al* (2016) investigate how interruptions impact radiologists' perceptions of workplace satisfaction, and suggest interventions in the form of separating IITs and NITs into specific workflows. They specifically suggest that NITs should be solely addressed by first- and second year radiology registrars, while IITs are completed by all other registrars and radiologists. This intervention and labelling is useful, and has been taken into consideration for formulating solutions later in this chapter.

Doshi *et al* (2018) also repeat this notion that non-interpretive tasks, many of which do not require a radiologist's training and skill, often lead to frustration when they cause frequent interruptions to occur. Their study looks more at how information technology (IT) can be used to improve radiology workflows between the different software they use. This can range from picture archiving and communication systems (PACS), electronic health records, and dictation software. This is a crucial part of radiologists' and registrars' working experience, but falls outside of the scope of this thesis to address due to the vast nature of the different applications, programs and workstations radiologists can utilise. It is definitely worth investigating.

Gualtieri (UX Healthcare 2020), a Senior Staff User Experience Design Engineer for General Electric HealthCare, highlights a different issue regarding the software radiologists use in his talk *One size fits all. Great for socks, bad for digital imaging products.* General Electric produces radiology equipment such as MRI and CT scanners, as well as x-ray machines. They also produce specialist software suites on which radiologists can view scans and x-rays. Gualtieri highlights that General Electric has traditionally developed its products with input from western academic institutions – large hospital systems with hundreds of radiologists and thousands of patients. While this has produced valuable insights and robust products, the needs and workflows of radiologists in Boston or San Francisco are not the same as a radiologist working in Nairobi (Kenya), Recife (Brazil), Surakarta (Indonesia), or Réghaïa (Algeria). General Electric have thus started to conduct research to understand their markets in these different areas, and customise their product offering based on the feedback from the developing countries.

[68] In the USA "registrars" are referred to as "residents". Their positions within the department and job descriptions are the same.

Lewis, Restauri and Clark (2018) note that limiting distractions and increasing radiologist efficiency may be a strategy for mitigating burnout. By reducing interruptions radiologists are freed up to spend more time on the parts of their jobs that they enjoy and find meaningful. Burnout and mental health among radiologists is discussed as part of the next section in this chapter. Lewis *et al* (2018) suggest two strategies for increasing efficiency: minimising distractions, and optimising the use of radiologists' time. One way suggested to minimise distractions is to employ or assign a "physician extender" or a "reading room assistant" who is responsible for answering the phone and is trained to answer common questions. The person (or persons) would have less of an expectation to do reading studies, and would help to minimise interruption of the majority of radiologists in the room. This echoes the suggestion from Lee *et al* (2016), who suggests that this person or persons could be first or second year registrars. Lewis *et al* (2018) also suggest taking short, scheduled breaks to increase productivity while working. This is part of optimising the use of radiologists' time. These breaks are already common among registrars at Universitas Academic Hospital who take regular coffee breaks and take this time to socialise and discuss cases. This research thus enforces the importance of these breaks.

Looking more generally at interruptions in healthcare, Li *et al* (2011) perform a literature review to understand the effect of interruptions on patient safety, and how to mitigate this. They note that interruption is a complex phenomenon, and that there is solid evidence from psychology regarding the impact that interruptions can have on human cognition. They highlight four main costs of interruptions, namely (1) resumption lag, (2) interruption lag, (3) total time on task, and (4) task accuracy. It is noted that having some form of control over *when* to deal with interruptions is less disruptive than having no control. Because of this, it is recommended that when possible, doctors may choose to delay the interruption they are facing (such as a phone call) until such a time as is convenient to them. This allows for more autonomy, but must be handled carefully, as the physician on the other side of the phone call also has needs (hence the phone call). This idea of allowing registrars to defer interruptions to a later time convenient for them is deemed valuable and has been included in the formulation of possible solutions as discussed in detail later in this chapter under *Futures* on 155.

Palma *et al* (2000) conduct three surveys to investigate the relationships between radiologists and physicians in the Department of Radiology at the University of Trieste, Italy. They find that the time devoted to daily consultations with physicians among radiologists amounts to roughly the standard work day of one full-time equivalent radiologist. It is also noted that at Ullevaal University Hospital in Oslo their clinico-radiological consultations constitute approximately eight hours a day; i.e. the cost of one extra radiologist daily. This is a significant amount of time for radiologists to be unavailable to conduct IITs. It is noted that the value of contact between radiologists and clinicians in daily practice is recognised, and such meetings are reported to have a highly educational role.

- **Perceived lack of understanding and respect for radiology**

The last five points (numbers 11-15) from the list of reasons why physicians are interrupting registrars hint at a level of animosity and frustration between radiology registrars and other departments' physicians. Other doctors at Universitas have not been consulted regarding these statements: this is how the registrars feel they are being perceived, and how they experience being treated. It is important to note that healthcare environments in general are prone to frequent and potentially intense conflict (Katz 2007). Friction between departments is not limited to between registrars and physicians; it can be found between various other disciplines as well. Some of the documented conflictual relationships that exist between disciples include between orthopaedic surgeons and anaesthesiologists, between orthopaedic surgeons and their surgical teams (Travers 2020), between surgeons and anaesthesiologists (El-Marsry *et al* 2013), as well as between physicians and nurses, physicians and physicians, and between physicians and families (Katz 2007:153). There are various reasons for the different conflicts,[69] and it serves to highlight that the conflict and frustration registrars experience in relation to physicians is unfortunately not an unusual occurrence in a healthcare setting.

The overarching frustration stems from the registrars feeling their work in radiology and their department are not respected. Some of it relates to the previous theme of "interruptions and distractions". Registrar 2 explains that other physicians "...feel like it's their right to come in and actually interrupt our daily workings. And as I look at these things, it's like interrupting a surgeon while he's operating to find out about another patient and then expecting him to stop everything and then go to the Ward and look at that patient." Registrar 4 repeats a similar sentiment regarding physicians coming into their department, saying that "I don't go into your house and come and demand things and come and distract you from your work like you do with me." Registrar 2 states that "people … [are] constantly rushing in, interrupting what we do, and actually there's no need for them to rush in. They can read our reports and we try to be as thorough as possible." Registrar 1 also explains that " …if you sit in front of a computer and you report a patient scan, it's similar to a doctor sitting in a clinic consulting with a patient face to face. If you're talking to a patient in a clinic, someone's not going to run in the door and quickly show you something or ask you to come and look or phone you …".

[69] Katz (2017) notes that differences of opinion are commonplace in work environments that are complex, high-stakes, and high-pressure, such as intensive care units, emergency departments, and operating rooms. Operating rooms have an especially high potential for conflict due to the broad range of different professionals that work together, such as physicians, nurses, and technicians. The operating room is also the only place in a hospital where two equal physicians simultaneously share responsibility for the same patient. For instance, a surgeon or orthopaedic surgeon, and an anaesthesiologist.

Another frustration is when physicians do not respect their hand-over hours between 8am and 9am every morning. During this period of time, the registrars that were on night shift will brief the registars who take over in the mornings on the cases they saw during the night. Registrar 4 explains that one of their friends is a surgeon, and does not understand the need for these hand-overs: "... she always … [complains] about … radiology. … why do you have hand-over hours? You don't have patients, you don't have things to hand over. But they don't understand that that hour where we sit with the guy that was on call, we go through the case [and] that is almost the only academics we get for that day. Where we go through a case and they'll say, okay, this is this, this is this. But now we sit there, the door opens five times, there's someone coming in, they want to book a scan, they want to book a scan, they want to ask about the sonar, or they want to please send this image. … Then we get irritated with them because now they're disturbing us between eight and nine. And then they're like, yeah, but you guys never work."

This perception that radiologists work 'less' than other departments or have it 'easier' is expressed by several of the registrars, as well as the radiologists that were interviewed. Registrar 5 explains that, "they just see us sitting in our chairs looking at [and] working on computers, which I can see from an outsider's point of view how that can look like an easy job… But when you're doing the job, especially if you're kind of new and it's taking you a while… the mental energy you use *is* energy. It is more taxing than you would actually think. [emphasis added by interviewee]". Radiologist 2 (2022) reiterates this idea that there is a perception in the medical world that radiologists sit in a dark room typing and not interacting; they have a very comfortable life devoid of things like rounds and call-outs to the Emergency Room. They state that this is true to some extent, but they can also work very long hours, which nobody else sees. They do get called out, but these call-outs are tertiary: while it is true they do not get called to attend to patients, they get called by doctors attending to emergency patients that require scans.

Because the departments use diagnostic scans in very different ways, that also affects the way other physicians believe radiologists should view scans. Registrar 5 elaborates that "If you're a surgeon, [or] if you're an internal medicine doctor … you spend [a] maximum [of] five minutes looking at a scan and you equate that with how long [you think] it should take [radiologists]. I think it's easy for them to forget that there are things that we pick up that they missed. And to be able to do that, you need to check everything every single time. Like incidental findings, certain incidental findings can be very important. That's something that I think is easily overlooked." To ensure incidental findings are always included fully, Registrar 7 takes the approach of "if it's not written, it wasn't done."

Registrars also face physicians' frustrations for situations they cannot control. For instance, if a Covid-19-positive patient is scanned or tests positive after a scan, the machine in question is not allowed to

be used until it has been disinfected by the hospitals' cleaners. Registrar 3 states that this has caused extreme delays at times: the machines could stand still for five or six hours while they wait, and physicians do not always understand when they are told this. Registrar 6 discusses this more in the context of being short-staffed at times: "… clinicians don't understand that we can also only do that much in the day. It's mainly quite draining. So if lists are overbooked or, for instance, I [will be] alone tomorrow at one of the hospitals, so I know it's going to be a tough day…".

When registrars get frustrated with the interruptions and disruptions, they do sometimes express this, which can be noticed by others. Registrar 3 remarks that, "A lot of the registrars can be very grumpy with other doctors. And I'm starting to realise why. I think [it is] the psychology of constantly getting asked for stuff that may or may not in different situations make your life more difficult…". Registrar 4 believes other people consider radiologists to be "mean", and that they "… always say no to … scans…". They state that they believe they are that person that will refuse requests from physicians, "… because I get so frustrated with the referring physicians, [when] they [send you a referral] or they want to scan, but [the] … reason [they give] does not make sense at all. That just frustrates me. The more … I almost want to confront them and say, but what you're telling and asking me doesn't make sense. And then they get irritated with me and they get upset and I get upset."

This leads to the next point, which is registrars' frustrations with other physicians in feeling that they do not spend enough time examining their patients. Registrar 4 gives the example of a patient that had been sent for a scan of their appendix, but upon readying the patient, the radiographer found a scar from an appendectomy – the operation to remove a person's appendix – and the patient confirmed that they had indeed had their appendix removed previously. Registrar 4 raises this as a concern that sometimes physicians don't speak to their patients enough or examine them thoroughly.

Registrars also sometimes feel undermined by physicians who insist on scans that they do not recommend, or scans done in a way that they do not recommend. Registrar 5 gives the example of someone whose appendix is infected, and has been referred for a sonar: "…if it's a large person that has a lot of subcutaneous fat and you're not going to be able to really see the appendix, then why not just go straight for CT scan? Because that's what you're going to do anyway. Now, the surgeons can't always see that coming, but it's something that we … do again, and again". They give another example in the case of a patient not being able to receive a contrast injection because their body will not be able to process it: "…if the renal function is horrendous and we can't give contrast and the doctors say, 'but can't we do an abdominal CT without contrast?' … no, you won't see anything, it's pointless. You're going to … ask me what I see and I'm going to tell you nothing, and then you're going to be annoyed with me because I'm not giving you the answer you want."

Registrar 4 adds to this, stating that because they are registrars, they often deal with pressure from other departments' consultants who are higher in the hierarchy than the registrars as they are already qualified. Registrar 4 states that, "…the other departments' consultants tend to bully us, the registrars in radiology. … you can't always say no to them because they're a consultant." They give the example of a consultant requesting three different kinds of CT scans for a patient (a non-contrast scan, a post-contrast scan, as well as a scan with oral contrast), when they would never do all three of those. The three possibilities for the patient's stomach pain have three very different ways of investigation, and work by a process of elimination: " …does the patient have a renal stone – where you do a non-contrast check – or does the patient have a bowel obstruction, – where you do an Xray to check – or does the patient have appendicitis, – where you examine then do ultrasound and blood. … And if you're still not convinced you do the CT." For Registrar 4 this comes back to physicians not thoroughly examining their patients: " …the fact that he wanted [to] look for all of those things, it just means that he himself didn't see or examine the patient. And who are you now to tell him, just examine the patient? …that's just frustrating. They bully us."

For Registrar 4 this frustration with the way other departments treat them has gotten to the point where they refuse to attend inter-departmental meetings without a radiology consultant present. Because they have few registrars in their department, one registrar would be on call and thus unavailable, one would be post-call, one at National Hospital, and one at Universitas, which leaves two registrars at Pelonomi Hospital: "… it's two registrars with another Department, their consultants, their registrars, their interns, [and] their students … I don't want to say abusive, but they're very attacking in those meetings. … At one point I said, I'm not joining a meeting if I don't have a consultant with me because the other department's consultants don't take you seriously because you're a registrar – what do you know? But still, they want a meeting with us and want our opinions, but they don't believe our opinions because you're a registrar."

Radiologist 1 states that they still experience that many physicians do not have that much respect for radiologists. They often see a radiology report as just another "test" to be done – of the same importance as a blood or urine test. They do not consider that radiologists need to determine the best way to scan for the particular question they want answered. They should involve the radiographers and then report on all of the findings of the study. The physicians only want a binary answer, and they want it right away. Radiologist 1 states that, "You don't get that kind of respect".

This idea that people feel unappreciated or underappreciated in their work is sadly not unusual, and numerous studies have documented this phenomenon. McGowan *et al* (2013) report on a study among 20 doctors in urban Irish hospitals and find that they feel undervalued and disillusioned due to insufficient training, perceived lack of power to influence change and intensive workloads. These

frustrations are similar to what the registrars at Universitas face. Singh *et al* (2019) conducted a study on junior doctors' morale in a UK hospital, and find that out of 402 respondents the average rating for *morale*, as well as feeling *valued* is 6 out of 10. Reasons listed for feeling undervalued include team work and relationships, workloads, lack of resources, and lack of feedback in various areas, including positive feedback. Van Niekerk (2006) also notes that South African healthcare professionals feel underappreciated.

A study by Fargen *et al* (2019) that surveys 320 neurointerventionalists[70] (highly specialised radiologists) in the United States finds that almost two thirds of respondents (65.2%) reported feeling underappreciated by leadership in their hospital or department. The study finds that there is a strong correlation between feeling underappreciated and burnout.[71] More than half of all physicians report professional burnout, a phenomenon which is documented to be significantly higher among physicians and medical students than among the general population. It often manifests in the form of depression, substance abuse, and suicidal thoughts. Suicide is the leading cause of death among male medical trainees, and the second leading cause of death in female medical trainees (Fargen *et al* 2019). According to Holmes *et al* (2016) between 60% and 76% of all registrar physicians experience burnout, and this number is steadily rising. A lack of work-life balance and feeling unappreciated are major contributors to this. However, very few seek help for this condition. This is largely due to an inability to take time off work, but also because it is a condition that is reportable to the medical board in America. Radiologist 1 (2022) is not aware of burnout being a condition reportable to the medical board in South Africa, because they do not think the medical board cares.

It is reported in the 2018 *Medscape National Physician Burnout & Depression Report* (in Lewis *et al* 2019) that radiologists experience higher than average rates of both burnout and coincident burnout and depression. Common themes for the causes of burnout are tedium of the actual job, decreasing compensation, and a lack of a sense of autonomy.

Several registrars at Universitas Academic Hospital discuss mental health and conclude that it does not feel to them that it is a priority in the department. Registrar 3 notes experiencing burnout due to increased workload and decreased staff numbers: " …the volume of work [does] not necessarily decreas[e] equivalent to the decrease that you have with your [staff] numbers." They feel that you learn coping mechanisms, but that burnout will happen "either way". Registrar 4 believes that in a

[70] Interventional neuroradiology is "a subspecialty of neuroradiology in which minimally invasive therapy can be effected by advancing various devices within a blood vessel to a point of a previously identified lesion – e.g. an intracranial aneurysm." (McGraw-Hill Concise Dictionary of Modern Medicine 2002).
[71] Burnout is defined as a combination of emotional exhaustion, reduced personal accomplishment and depersonalisation associated with work (Maslach & Jackson 1981). It is classified as an "occupational phenomenon" in the International Classification of Diseases (ICD-11), not a medical condition (World Health Organisation 2019).

state hospital you burn out less quickly, because the workload and hours are more controlled than in private practice. The implication is also that it is inevitable. Registrar 5 states that the idea of taking a "mental health day" is unheard of: " … you will not be able to live that down in a group of doctors. They will judge you and they will just look at you completely differently." They also state that a large reason for that is because the other registrars would need to absorb that person's workload, and there is no capacity to do so. Any person that takes leave affects the other registrars directly. If someone takes sick leave for their mental or physical health and someone else needs to cover their on-call shift, it can be traumatic, "because it's so disruptive to your life. … [Y]ou plan these things … a month ahead, and when you are the only person that's not on leave and not post-call … and not writing an exam and … you [are] …the only one that can do it. That creates animosity."

There are various other frustrations that registrars aired and are briefly summarised below in no particular order:

- The FUJI PACS system is not user friendly
- They feel a lack of control over their environment and workspace, and there is a lack of communication from the hospital
- Frustrations regarding admin tasks
- There are frustrations regarding machinery and IT issues
- The IT support team is not always able or available to assist
- Sometimes people on the team do not contribute equally
- They feel that mental health is not a priority: some registrars have experienced burnout, and feel it is inevitable
- There are not enough registrars for all of the work to be done
- There is a lack of consultants to oversee their work
- Waiting for patients and delays are frustrating
- Turn-over of colleagues is frustrating. Registrar 3 states that " … we had many colleagues coming and going and that actually kind of broke the Department down."

- **The importance of community to a radiology working environment.**

All of the registrars consider community and camaraderie to be very important to a good radiology working environment. Registrar 5 states that, "I … like the sense of community, the camaraderie, the radiographers". Registrar 4 likes the "… camaraderie between the radiology registrars. That's nice. … I must say we are a really nice group. … it's nice to have a good camaraderie between everyone and everyone has each other's back[s] and we help [one another]." Registrar 2 adds that, " …we have a very good camaraderie, a very good support system."

Registrar 3 enjoys the casual conversations with colleagues: " …it takes effort to build … relationships and you need quite good relationships at work to really make it work in [the kind of] situation that we've been through [with Covid-19]. … That's one of the things that I enjoy, having a good chat and still being able to do your thing."

A department with a good atmosphere is also deemed important. Registrar 4 states: "We have a nice Department. I always say you're happy if you have nice people around you. If you work with nice people, then you'll enjoy your work, especially with radiology."

Registrar 7 remarks that because of the open layout of the working environment at Pelonomi Hospital, it fosters a good sense of community: " … you can just turn around to your colleague and ask them for [their] opinion. It creates a sense of camaraderie … And everyone … offer[s] everyone coffee. So there's more [of] a community spirit …". However, it's more difficult at Universitas, because, " … you're not in the same space. So it's not as easy to ask an opinion from your fellow colleague. And it is not as easy to offer coffee or you would have to get up and walk [to them]."

Trust is also very important in a radiology working environment. Registrar 2 notes that, "You have to trust the person next to you and you can't be monitoring who goes where the whole time. It's [a] whole team effort." Registrar 1 also reflects this idea of teamwork by stating that, " …I think being part of the team … in our radiology Department at the moment, I feel like we have a very nice, coherent group … I mean, we've had some hardships lately… And I think that brings people together and sort of motivates everyone to work towards the common goal."

This sense of "working together" and being a "team" carries over to the registrars going out of their way to assist one another. Registrar 2 notes that, "We support each other. If you see someone that's falling behind you try to help. If they have … a question, … no one will bite anyone's head off or make anyone feel stupid if they have a question." Registrar 5 also notes that once they're finished with their reports they'll see if someone else needs help. They also state that a registrar once came out to assist them with a procedure at 5am because they knew the consultant would not. Registrar 3 notes that if someone can't find the blood results of their patient, they'd help them search for it. Registrar 3 also adds that they look to see how they can help their co-workers, and also try to take things off Professor Janse van Rensburg's plate, as they know he is very busy.

This leads into another topic raised: the importance of a good Head of Department (HOD) to a good radiology working environment. Registrar 3 believes that you need good leadership with a vision for the department who also cares about the people. Registrar 5 adds that the HOD needs to be good at deescalating situations. Registrar 5 notes that their HOD helps with the camaraderie of the

department, and does not, " …crack the whip too much." The HOD ensures that the team doesn't need to take on a lot of extra work that will not benefit them academically. He manages the registrars' workload by ensuring that, "The amount of lists that can be covered is determined by the number of registrars, not determined by what the [heads of other departments] want. … So there's definitely a feeling that the Head of [the] Department cares about us as people."

The registrars also foster their own sense of community by getting together for breakfast every Friday morning at a specific restaurant close to Universitas Academic Hospital. Registrar 1 calls this their "standard non-meeting", while Registrar 6 explains that this allows them to talk about their week. Registrar 5 adds that it allows them to talk to one another outside of a work environment.

Some of the registrars mention the idea that the department is their "home", and take pride in the space. Registrar 4 states that, " … this is our home. You spend … 8 hours a day [there]". One of the registrars brought an old radio from home and put it in the department so that there is background music playing for them. For Christmas two of the registrars bought and put up Christmas lights and tinsel: Registrar 4 repeats the sentiment that, " …we try to make it nice because, like I said, you're spending 8 hours of your day there."

Because of this sense of "community" and "home", registrars have taken ownership of their space, and current and past registrars have implemented some improvements at their own cost. At Pelenomi Hospital the head of department installed a water filter in the kitchen for the radiology department, and the current registrars replace the filter annually, which works out to R50 per person per year. The team also has an on-call room – a room where the registrar working at night can rest or sleep when they are not needed – that Registrar 4 describes as "nice". It has its own bathroom with a shower and a bed. Professor Janse van Rensburg bought a new bed for the on-call room at the beginning of 2022: Registrar 4 notes that the bed they have in the room now is nicer than the one they have at home. The registrars take turns to wash the linen: if they're on call on a Wednesday or a Saturday they take the linen home to wash, and that way they ensure there's always clean linen. Registrar 4 also notes that their environment is always clean: cleaners clean their kitchen and reporting rooms regularly. Registrar 3 adds that the cleaners buff the floors at 2am to make them shine.

Another way the registrar team has created a sense of community is around coffee. Registrar 7 states that, " … coffee generates … a sense of community or camaraderie and also gives you something to just do for a moment while you breathe." When asked what they like about their working environment, Registar 1's first reaction was to joke that they're " … tempted to say the coffee." Although they clarify that it goes deeper than just coffee: "… I suspect it's more of a social thing than the actual coffee itself.

Like taking a smoke break. Like, let's have a cup of coffee first, let's just stop and regroup, and then we'll take it from there."

The registrars buy their own coffee for the department; Registrar 4 notes that " …everyone chips in". Registrar 2 adds that they ensure their coffee is very good. Some days they will make a big pot of filter coffee, other days they will drink instant coffee, or if they are feeling "fancy": tea. The first thing that Registrar 7 does upon arriving at the department is to fill and turn on the urn for coffee. Registrars 1, 4, 5, and 6, all note that the first thing they do upon arriving is to make coffee. Registar 2 states that the first thing they do is to make sure everyone has a cup of coffee. Registrar 3 mentions that during the day people bring you coffee or you take coffee to other people, to make them feel "happy" even though they might be very busy. Registrar 2 adds that you start to know everyone's coffee order; nobody makes coffee just for themselves. Registrar 5 goes on to say "lots of coffee" is an important feature of a radiology working environment.

The registrars have a WhatsApp group for communication, and Registrar 5 notes that before they even started they were surprised by all the messages that impressed on them how important coffee is to the department, as well as lots of memes that were shared about coffee. There is a running joke in the department that coffee is more important than the radiology machines, as Registrar 5 notes: " …the CT scanner broke once. And everyone just said, 'well, at least the coffee machine is working.' So it's part of the camaraderie, it's part of the culture of the place that coffee is very important." Having coffee gives them a chance to take a break and socialise: "It's a time when we chat about work things and non-work things, but not having full on academic discussions."

Other factors that are considered to be important to the department are the following, in no particular order:

- Having enough staff and specifically enough consultants
- Having reliable, efficient, and quality equipment
- A head of department with vision (Registrar 3), that cares about people, is a leader (Registrar 3), and is good at deescalating situations.
- Good communication (Registrar 3)
- Good academics
- Reliable staff: radiographers, radiologists, and cleaners
- A good admin team, as they are the entry-point to the department
- Established relationships and being a team player

4.3.2 Establishing the core paradox

Now that we have investigated the feedback from registrars concerning their environments, it is clear that the space in which they find themselves contains numerous issues that are intertwined and affect one another. This indicates that it is indeed a *problem space* as discussed in Chapter Three (page 72) and not a singular problem, or even multiple but separate problems. The problem space is considered ill-structured according to the list of characteristics[72] that Simon (1973:183) presents, and it is also *wicked* according to Rittel's (1922:13) properties[73] of wicked problems. This is due to the complexity of the environment, the various actors involved, the nature of a healthcare space, and the involvement of a government entity.

As discussed in detail in Chapter Three (page 72), it is difficult to determine a set problem or solution at any given point in a problem-solving exercise as they do not exist or evolve independently. Instead they exist as aspects or moments of a single concept. This has indeed been the case in this research. As understanding of the registrars' environment grew, more opportunities for solutions came to the forefront, which in turn revealed other potential issues to be dealt with. In order to comprehend these complexities, we seek to first understand what makes the problem situation hard to solve. What is the core paradox that keeps the situation from moving forward? This is expressed in a series of "because" statements, outlined as part of Dorst's Reframing design process.

Several standalone paradoxes are at play in the radiology working environment at Universitas Academic Hospital, as stated below.

- *Because* registrars focus while reporting, they do not like to be interrupted.
  Because physicians need information from registrars, they interrupt them.
  Because registrars are interrupted, they take longer to report on scans.
  Because registrars take longer to report, physicians may interrupt them to get information on their scans.

- *Because* physicians need to talk to registrars, they interrupt them.
  Because registrars are interrupted, they get frustrated with physicians.
  Because registrars are frustrated, they are less likely to want to engage with physicians.

- *Because* registrars feel like they are "looked down upon" by other departments,

[72] A detailed list of these characteristics can be found on page 71 in Chapter Three.
[73] The list of properties can be found on page 76 in Chapter Three.

they have created a strong sense of community within their own department

Because they have created their own sense of community, they are wary of "outsiders"

Because they are wary of "outsiders", they are less likely to engage with other departments

Because they are less likely to engage, other departments don't fully understand their work, and may "look down" on them

4.4 Ideation and Refinement phases

The next two phases in the design thinking reframing process have been combined because, although they happen consecutively, it is more succinct to discuss and write them as combined. The fourth phase, *ideation*, is divergent, and aims to generate ideas that can be used to solve problems. This is a 'safe space' where no ideas are bad – the aim is simply to generate as many ideas as possible. Methods used for this phase include brainstorming and ideation, as well as literature review to investigate previous attempts to solve known problems.

The fifth phase, *refinement,* is convergent, and aims to critically assess the ideas generated in terms of suitability and feasibility, potentially merging ideas as they get refined. The two phases have therefore been combined in order to present the best ideas in the optimal format for this thesis.

This section addresses the third objective of this chapter, which is to formulate hypotheses of possible solutions to problems that have been identified.

4.4.1 Frames

Applying new frames to the existing problem space is at the heart of what Dorst aims to achieve through his framework. It requires that one think of a current problem situation *as if* it were something else, which may lead to a different way of thinking.

Based on the three main themes identified during 4.3.1, frames have been created that place each of these at the centre of the solution. As a reminder, these themes are:

(1) perceived lack of understanding and respect for radiology,

(2) the importance of community to a radiology working environment, and

(3) frustrations arising from interruptions and distractions,

Next, the themes are discussed and expanded upon.

- If the problem situation of the radiology working environment is approached as if it is a problem of lack of understanding and respect from other departments , then …

  Empathy between departments needs to be encouraged, so that doctors in various disciplines can have more respect for one another.
  This concept in itself is a wicked problem, as there is no singular (obvious) cause of this perception between departments. There are various ways in which interdepartmental relations can look to be improved though, such as communication and raising awareness. Mamlouk *et al* (2013) raise the question whether a radiology report is becoming equivalent to a complete blood count in a physician's eyes. This sentiment has already been echoed by Radiologist 1 (2022) earlier in this chapter, stating that sometimes physicians see a radiology report as just another examination to be done, the same as a blood test or a urine dipstick. They feel physicians do not consider the detail required in preparing for a study. Radiologists think about it being a CT scan with contrast, that the radiographer needs to be involved, and afterwards they need to report on it and compare the scan with previous ones. Physicians want a binary yes-or-no answer though, and do not consider the detail that has gone into it.

  Mamlouk *et al* (2013) suggests that this 'commoditisation' of radiology is to a large extent because of the lack of communication between radiologists and physicians. They also suggest that radiologists need to learn to be helpful consultants during their training. Building on this train of thought, a solution which has shown promise in bridging this gap is to include a registrar in physician patient rounds. This approach has been implemented in two pilot studies by Mamlouk, Anavim and Goodwin (2013) and Aripoli *et al* (2016), who call these "radiology rounds". It involves the registrar reviewing images with the clinical team on a projection screen to discuss pertinent findings, demonstrate pathologic processes, and discuss the appropriateness of further radiologic examinations The patient is also shown the scans, and takes part in the discussion.

  These pilot studies were conducted over 2 weeks (Malmouk *et al* 2013) and 20 weeks (Aripoli *et al* 2016) respectively. During this time it not only fostered a greater camaraderie between physicians and registrars, but also improved the working relationship, as well as improved patient care (Aripoli *et al* 2016). 95% of clinicians stated that they would like a future radiology registrar to do rounds with the clinical team (Malmouk *et al* 2013). More physicians felt that the registrar was credible (36% pre- to 63% post-pilot), and significant increases were noted among the number of physician respondents who felt the resident showed interest in helping the clinical team, and that the resident provided relevant information. 80% of registrars noted that incorporating consulting skills into registrar training was beneficial to

education, compared to 40% pre-pilot. This process thus ensures that registrars become visible in patient care, and establishes trust between physicians and registrars, along with credibility of their radiological interpretations.

- The same frame as previously stated can also have another solution applied to it:
  If the problem situation of the radiology working environment is approached as if it is a problem of lack of understanding and respect from other departments , then …

  Departments need to communicate better, to ensure collaboration can occur for the best patient experience.

  Communication between different departments in a hospital is vital to ensure the best patient care. Marshall Rosenberg (2015) presents a method to improve empathic communication, which he terms "nonviolent communication". This approach can be used to truly understand what someone else is asking, before responding. The process entails four steps: observing; expressing emotion in relation to what you observe; expressing needs that cause your feelings, and articulating requests that would enrich your life without demanding. By practising this approach, registrars and physicians will be able to communicate better without blaming or criticising one another.

  Workshops could be held to practise nonviolent communication, and can be included as seminars that doctors can attend. Considering how often friction occurs within a healthcare setting – according to one study at least 20% of physician executives' time is spent resolving conflict (Aschenbrener & Siders 1999) – it is a topic that all healthcare workers can benefit from.

  A lot of research has been conducted on doctor-patient empathy and teaching empathy to doctors in terms of approaching patients, but little research has been done on how doctors should treat one another with empathy.

- If the problem situation of the radiology working environment is approached as if it is a problem of other departments feeling like 'outsiders', then …

  Other departments can be invited into the radiology community.
  By making the radiology department a warm and welcoming environment that caters to physicians from other departments and is considerate towards them and their time, it sets the tone for the rest of the engagement between registrars and physicians. Suggestions on how

this can be achieved is discussed later in this chapter.

- If the problem situation of the radiology working environment is approached as if it is a problem of distractions and interruptions, then …

  The number of disruptions should aim to be reduced
  In an ideal working environment registrars would not be disrupted or interrupted at all. This would allow them to concentrate while reporting and ensure that their reports include all of the detail necessary, without the risk of forgetting to include something because their train of thought was interrupted. No distractions or interruptions would also ensure a faster turn-around time and lessen frustrations. In practice this is not practicable or possible since, as has been described in detail in the *Themes* section, physicians have questions that require input, and are unavoidable. Physicians and registrars need to collaborate to provide the best possible patient care. What *can* be addressed is how registrars react to these distractions, and what processes can be put in place to lessen or improve the number of distractions and interruptions. This is investigated in more detail later in the next section under 4.4.2 *Imagining Futures*.

  A lot of research has already been conducted regarding managing interruptions and distractions, and this thesis draws on that body of knowledge in order to propose solutions. Sykes (2011) notes that collaboration is an important aspect of almost all workplace environments. The trade-off is that more collaboration means more interruptions in workflow. There are four known strategies for managing interruption: (a) immediate, (b) scheduled, (c) negotiated, and (d) mediated (Allen, Guinn, & Horvitz 1999; McFarlane 2002). By taking these different strategies into consideration, suggestions for solutions to be further explored have been formulated in the next section under 4.4.2 Imagining Futures.

Disruptions and interruptions occur in various other fields – not just radiology – and therefore it is important to consider other iterations of this frame.

- If the problem of interruptions and distractions is approached *as if* it is happening in a classroom, then …

  Methods used by teachers to discourage students from interrupting or being distracting can be utilised.
  These could range from not acknowledging the interrupter until such a time as it is deemed

convenient, to signs that remind people not to interrupt during certain hours.

- If the problem of interruptions and distractions is approached *as if* it is a problem of physicians seeking information, then …

  Physicians should be able to get information or get feedback from other resources or avenues, besides registrars.

- If the problem of interruptions and distractions is approached *as if* it is a problem of registrars being doctors to other doctors, not to patients, then …

  Registrars should borrow from the way physicians interact with patients.
  As Registar 2 (2022) notes: "[Radiologists] are not doctors to patients. [They] are doctors to doctors." By entering this mindset, the structures and protocols that have been put in place for physicians to interact with patients can be utilised in in a similar manner with physicians. This may include a waiting room, drinks stations, material to read.

4.4.2 Imagining futures and transformation

Imagining futures is a "thinking forward" exercise as part of Dorst's reframing methodology (2015), that aims to investigate possible solutions created via the frames as mentioned above. By taking the frames as a starting point and combining them where possible, there are a number of new ways of thinking that can be applied to formulate possible solutions to the frustration of interruptions and disruptions. The number one aim is to improve working environments based on the themes identified earlier in this chapter. *Transformation* on the other hand (which is also part of Dorst's Reframing) evaluates the feasibility of different kinds of frames and solution directions. While these are separate steps in theory, in practise it is natural to critique and assess the viability of a solution as it is brainstormed and considered. They are thus written as one concept in this thesis, as opposed to different sections which would require repetition.

By building on the idea of thinking about the radiology department in other contexts as established by the *frame creation* exercise, we can introduce established processes that have been shown to work in these environments. To this end, the following hypotheses of possible solutions are suggested:

There are two main "actors" at play in the radiology department: the radiology registrars, and physicians from other departments. Their roles are interwoven and each needs the other to successfully treat patients. In order to create a sense of harmony between them, I recommend an

attempt to remove the "us" versus "them" mentality that has been unintentionally introduced, and instead suggest scenarios and solutions where goal alignment and empathy are used in order to encourage collaboration.

Before moving on to concrete point-by-point suggestions backed by academic research, I first wish to paint two scenarios where the experiences have been improved, one from the point of view of each of the actors. We begin with the registrars.

Imagine yourself as a fourth-year radiology registrar. You are reporting on the MRI modality today, and you are deep in thought investigating an unclear spot on the corner of an image of a left lung. Out of the corner of your eye you notice a notification light up on your cell phone. You know you can dismiss it as something to be dealt with after you've finished reporting on this scan; one of your colleagues would have gotten your attention if you were urgently needed. You continue your investigation for another five minutes, reading up on other reference material, concluding and noting that the "fuzziness" is the result of an enlarged lymph node. You pick up your cell phone to check the notification, and notice it is from the department's self-help kiosk. At first glance it states "Dr Saleem – waiting", and once you tap to expand it, additional information is shown: "Patient transfer from Pelonomi – Mr FA Bakesi." You get up and make your way to the physician consultation room, while thinking back to your first and second years as a registrar when you were one of the physician liaisons. You are grateful you do not need to answer the department's telephone any more, but you also realise how much you were able to learn by asking the right questions through that exercise. You walk into the physician consultation room and find Dr Saleem on the couch reading a journal article on his cellphone, and ask him to join you at the radiology workstation to go through Mr FA Bakesi's MRI scans from earlier this morning. After your discussion is concluded, you thank Dr Saleem for waiting and walk back to your workstation, grateful that the physicians no longer walk into your space and interrupt while you are working.

Next, we consider the same scenario, but from the point of view of the visiting physician. Imagine yourself as a physician with a question for a specific registrar, walking into the radiology department. You have heard that the radiology department has put new procedures in place to improve the physician's experience, and this is the first time you're going there since it was implemented. Upon walking into the radiology department, you notice a sign directing you to the new consultation room for physicians. Curious about what awaits you, you follow the clear signage which leads you to a separate room nearby. Upon entering you notice a tablet on a table with the words "Welcome to the Diagnostic Radiology Department" (Figure 43). You fill in the four questions: (1) "What can we help you with today?", (2) "Your name", (3) "Do you need a specific registrar to assist you?", and (4) "Would

you like to wait or roam?" You fill in the form and select the choice to wait. After clicking the "submit" button the screen tells you that a physician liaison will be with you shortly.

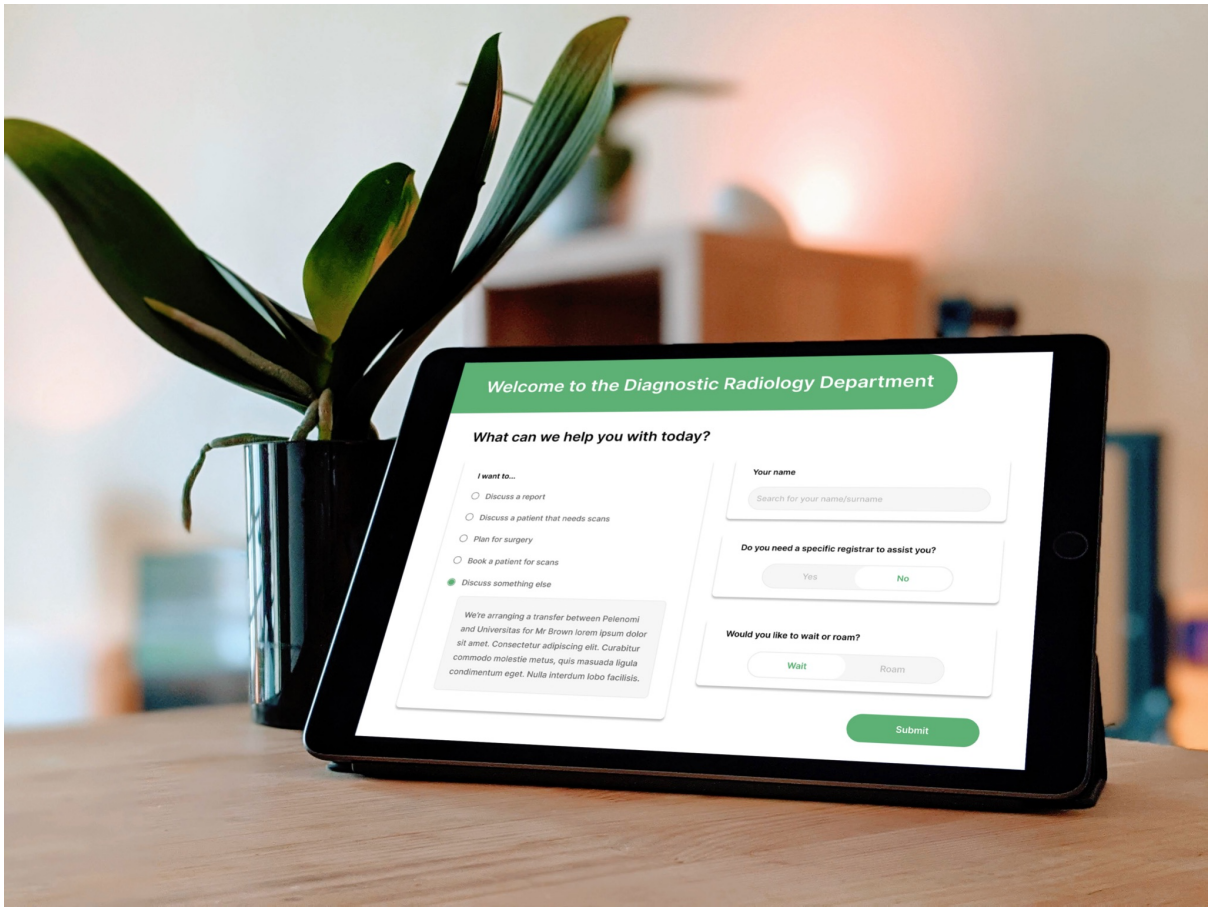

Figure 43: A mock-up of a proposed self-help kiosk for physicians. Photograph by Agitalizr, 2020, interface design and mock-up by the author, 2022.

You look around the room and notice a drinks station, a radiology workstation with different QR codes shown on its screen, a table with six chairs, and a comfortable couch. You make yourself a cappuccino following the instructions on the machine, and have a chuckle at some of the coffee-related jokes posted against the wall while stirring in your sugar. You walk to the workstation where the QR codes are displayed, and notice they are links to the latest journal articles for different fields as they relate to radiology. Using your cellphone you scan a QR code for a journal article on MRI staging for colo-rectal cancer and sit down on the couch to start reading. In a short while the physician liaison enters to assist you with your query, and informs you that the registrar you need to speak to about the patient transfer is currently busy with a report, but will be available in five to ten minutes. You decide that you have time to wait instead of coming back later, inform the liaison of your decision, and sit back to read your article. Five minutes later the registrar you need to see enters the room, and calls you over to the radiology workstation to go through the report of the patient you requested. While you are busy with your consultation, another registrar enters the consultation room with two physicians, and they sit down at the table and chairs: they are discussing an operation to be performed, which they are viewing on a screen.

When you are done discussing your patient transfer, you thank the registrar for the excellent coffee, and continue on with your day. As you walk down the passage back to the surgery department, you think back to how unexpectedly pleasant your experience in the special physician consultation room was. They've really made an effort. You make a mental note to tell your colleagues the joke about the coffee cup you saw.

Below the various interventions suggested in the different environments are discussed, and supported by academic literature.

- **Self-help ticketing system**
  As a means to freeing up time to allow registrars to plan their days better, I suggest creating a website and/or mobile app where physicians can log "tickets" and also potentially book time with registrars. It will primarily be available on a tablet in the physician consultation room, where physicians can interact with it directly. As a next stage it could also be available on physicians' phones where they could book time remotely or check registrars' availability before heading to the radiology department. They could also ask to be called instead of needing to be seen. This would reduce the need to wait for registrars, and improve the physicians' experience of the radiology department.

  This suggested system utilises the *scheduled*, *negotiated,* and *mediated* interruption strategies, as mentioned earlier in this chapter (Allen *et al* 1999; McFarlane 2002). It can be *scheduled* in the case where a physician chooses to book time with a registrar, thus allowing them to plan their day around this expected interruption. In the case of a *negotiated* interruption, the physician logs a ticket on the self-help kiosk, and the registrar attends to it when they are able. A *mediated* interruption would occur when physicians interact with the physician liaison, who is then able to field their query and either provide an answer, or guide them to the right person to assist them.

  Physicians will only need to answer four questions in order to log a ticket on the self-help system:

  1. **What can we help you with today?**
     This question lists various options to be chosen, as a means to speed up the selection process. The options are grouped based on interviewed registrars' feedback regarding their most common queries. Physicians can say that they want to "discuss a report", "discuss a patient who needs scans", "plan for surgery", "book a patient for scans", or "discuss something else" – which opens up a freeform text field to enter details into.

2. **Your name**

   Once the physician starts typing their name, the system will search the hospital's database and make suggestions for them to select. This ensures that the correct physician is logged against the ticket, and that the correct phone number is used if the registrar needs to phone the physician.

3. **Do you need a specific registrar to assist you?**

   In some cases any registrar or a liaison will be able to assist, such as if the question or request is general. However if a specific registrar wrote a report and a physician wants to discuss that report, they will want to speak to that specific registrar who wrote it and already has the context of that case.

4. **Would you like to wait or roam?**

   Physicians are busy people, and we want to take that into consideration. Here they are given the option to either wait in the consultation room, drinking their coffee or reading their journal article, or get back to what they were doing previously, and will be notified once the registrar they requested is available to assist them.

After a ticket is created on the platform either the liaison (if no specific registrar was selected) or the specific registrar will receive a notification of a ticket. The ticket will list the specific details that the physician filled in. The liaison will immediately attend to their tickets, while more senior registrars will attend to the tickets when they've concluded the report they are busy with at that moment. If the physician has selected that they would like to roam, the registrar will notify them via the app or SMS once they are available. The physician will receive a notification on their phone informing them of this.

- **Introduce a physician liaison for attending to non-image-interpretive tasks (NITs)**

  It would be invaluable to registrars to have someone whose sole responsibility is answering the department's phone and attending to requests like scheduling patients, or direct questions to the appropriate person. Unfortunately this would require appointing an additional person to the staff, which would mean an additional salary expense. As has been discussed before, budgetary constraints within a public hospital are not something that registrars or even the department head really have control over. So while this is something that the HOD could motivate for, it is unlikely to occur. As it may be difficult to appoint a new person dedicated to attending to non-interpretive tasks (NITs), the approach as used by Lee *et al* (2016) can be utilised: appointing first- and second-year registrars to attend to NITs where possible, on a rotating schedule. This will involve answering the phone, attending to physicians visiting the department, and other NITs as they emerge. While this will not eliminate the need for more senior registrars to attend to physicians – if a physician wants to discuss a report, they will

want to discuss it with the specific registrar who reported on it – it will significantly reduce the number of disruptions.

- **Prioritising disruptions**

  One of the issues concerning disruptions is that they often come through at the same time, with no consideration for urgency, priority, or importance. Level of importance for a registrar compared to a physician's considerations can also differ vastly. If a physician has only one query, it is obviously very important for them to have it answered. However, a registrar may have several queries from different physicians and different departments simultaneously to attend to, as well as reports waiting to be written, and struggle to prioritise accordingly.
  A telephone ringing demands to be answered, although the request that comes through may not need to be carried out immediately, or necessarily be more urgent than other queries.

  In order to help the designated registrar liaison prioritise urgent versus non-urgent disruptions, I suggest using a system doctors are already familiar with, namely "triage".
  In medicine, triage is used to determine the order in which patients should be seen in an emergency room based on the urgency of the care they require (Merriam Webster Dictionary [sa]). In South Africa triage coding consists of four colours: red for immediate attention, orange for very urgent management required, yellow for urgent treatment required, and green for non-urgent cases (Life Healthcare 2021). In an emergency room, triage is performed by the intake nurses, to ensure patients suffering a stroke (red – immediate attention) are seen before patients that need script refills (green – non-urgent), and not in the order in which they enter the waiting room. This organisation and prioritisation is currently missing from registrars' working environment.

  What is also missing and vital to the triage system, is a way to perform triage in the first place. As mentioned, in an emergency room, this task is performed by intake nurses. In the radiology department there are no nurses on staff, and radiographers are busy with their own tasks, therefore this task currently falls to registrars. A possible solution is self-help kiosks (Figure 42) in the waiting room, but can also be physically performed by the liaison.

- **Introduce a physician consultation room**

  Upon entering a physician's practice, you first walk through a waiting room, before getting to a receptionist. You cannot simply walk into a doctor's office while they are busy with another patient or not ready for the next patient. This same principle can be introduced in the radiology department, where physicians can wait until the registrar they need to speak to is available (if specific) or until the physician liaison (discussed later in this section) can attend to

them. This room is separate from the patient waiting room, and set up in a way to be specifically usable to physicians and registrars.

- **QR code screensavers**

  Advances in medical technology are constantly being made, and healthcare professionals are required to stay on top of these changes. As part of their jobs radiologists and registrars read journal articles to gain new knowledge. This knowledge can be shared with physicians, by putting up screensavers that allow them to scan QR codes that open the articles on their phones. These screensavers can be made monthly or bi-monthly, whatever makes sense depending on how often new novel research is posted for various disciplines.

- **Radiology workstation for visiting physicians**

  While a radiology workstation already exists for visiting physicians to use, it has been noted that this is rarely used – the physicians end up sitting with the registrars at their workstations. This can be disruptive to other registrars in the room, as a conversation may interfere with their dictation. Registrars may also feel obliged to talk to or greet the physician, further introducing distraction. By moving the visiting physician radiology workstation to the consultation room, physicians will have the opportunity to view the reports that they want to look at ahead of their meeting with the registrar. This could also enable them to look at reports along with the registrar during their consultation.

- **Table, chairs and screen for consultations**

  At present, when physicians consult with registrars for whatever reason, this occurs in the same space where other registrars are busy reporting. This is an additional distraction introduced to the environment. When registrars discuss scans with physicians, this happens on their own workstations or computers, which means that they need to close everything they are currently busy with, and locate a different report or scan. By setting aside a dedicated space for consultations, a distinctive place is created between where registrars report, and where they interact with physicians. This will assist in reducing distractions.

- **Introduce a drinks station**

  Since coffee is such an important part of registrar culture, this can be shared with visiting physicians. Coffee-related decorations, jokes, and designs can be introduced which will serve as reading material/entertainment while waiting, such as an infographic related to the department's coffee-consumption, or memes that the registrars regularly send one another. Other hot- and cold drinks can also be provided as a way for physicians to take a quick break. As physicians are very busy, this may be the only kind of break they can afford before continuing with their work.

- **Introduce a rotation for registrars to attend physician patient rounds**
  As explored by Malmouk *et al* (2013) and Aripoli *et al* (2016), I suggest including "radiology rounds". As studies suggest, this has the potential to improve empathy and communication between physicians and registrars, as well as improve registrars' consultation skills. This is something that would require "buy-in" from registrars and the department, as it is not my intention to add additional workload onto already stressed registrars.

- **Introduce workshops and seminars on nonviolent communication**
  In order to assist registrars with communicating as seamlessly as possible, it would be beneficial to introduce workshops and seminars on nonviolent communication as introduced by Rosenberg (2015). By teaching registrars ways to truly understand the other person and respond in a manner that they will be open to receiving, it can assist in reducing and avoiding interdepartmental conflict.

4.4.3 Integration

During this step it is important to consider how these new frames will fit into the broader organisational context.

By creating a space where physicians feel welcomed and attended to, it is likely to not only help with inter-departmental camaraderie, but also lessen frustrations from registrars. By improving interpersonal relationships, physicians will hopefully be more patient when needing to wait, and registrars will continue to assist as soon as they are able.

By lessening interruptions and distractions for registrars, they will be able to improve on the speed at which they report, which will in turn cut down on interruptions in the form of asking where reports are.

The self-help ticketing system will alleviate a lot of pressure from physicians needing to walk into the department, as well as allowing them to schedule time to talk to the registrars. As a first stage it can be built as a responsive website that will be able to work on desktop computers, tablets, and cell phones. However, money would need to be invested in order to pay for software developers to create the relevant software, as well as user experience (UX) and user interface (UI) designers to assist with the design and creation of the interface and information structure. Costs would also be involved for registering a website domain and to host the website. Permission would need to be granted by the hospital and department in order to integrate with their database of physicians and access contact details. The website could still be built without this integration, although it would be less intuitive and

user-friendly. An idealistic outcome of this exercise might be that it works so well that the whole hospital would want a variation of the system to be integrated into their departments.

Adding the idea of a physician liaison does not require additional manpower or incur additional expense, except in the form of time that will be required from first- and second-year registrars. They will learn from this opportunity though, and physicians will receive personalised feedback, which will in turn improve interdepartmental relationships.

Introducing a physician consultation room, while potentially very helpful, poses the biggest challenge. Space is a highly sought-after commodity in any hospital, and the suggestion of turning any space into a consultation room may be met with hesitation or resistance. Luckily, within the diagnostic radiology department at Universitas Academic Hospital there are two existing spaces that could work for this suggestion. The first is a boardroom at the back of the department that could be converted to accommodate all of the proposed suggestions. The second possible room, which is in the centre of the department, is ideal. It is currently used for inter-departmental meetings and already contains a radiology workstation and a projector, along with tables and chairs. This “meeting room” as it is known has all of the basic requirements to be an ideal physician consultation room. It is also inside the department so it would not take registrars away from their reporting environment for too long. It is also possible to build a new room, but this again incurs costs, which has time and again been shown to be tricky within a government setting. Fortunately, it is unnecessary as the board room and meeting room are viable alternatives.

As registrars and consultants naturally read the latest articles related to their field, introducing the idea of creating QR code screensavers that link to the articles would not be too much of an imposition. The QR codes would need to be generated – this can easily be done online for free – and then the static image screensavers would need to be created and saved on the consultation room’s computer. The radiology workstation for visiting physicians that is already in the meeting room can be used for this.

4.5 Next steps

Now that hypothetical solutions have been generated to address the main themes gleaned from insights generated by registrars, the next step in the process would be to present these solutions back to the registrars. It would be ideal to workshop the proposed solutions with them, to ensure that solutions are feasible and address their concerns. This would entail more of a participatory or co-design approach, whereas to date the approach has emphasised an empathetic design approach, which is researcher-led.

Once solutions have been assessed by the registrars at Universitas Academic Hospital, surveys can be sent out to other universities' radiology departments to determine whether these solutions may be feasible for them as well. If not, then the same process undertaken at Universitas Academic Hospital can be repeated at other institutions. Owing to time constraints it is not possible to conduct these studies at this time. It is instead referred to further study in future. The value that a human-centered design process can bring to a problem space is evident, and allows for a different way of considering environments.

4.6 Conclusion

This chapter has applied the design thinking reframing process as set out in Chapter Three to a case study – probing and scrutinising the working experiences of radiology registrars at Universitas Academic Hospital in Bloemfontein. By following this process I confirmed that the design process is not linear, and that a diagram trying to show it as such for the sake of simplicity and aesthetics does not include practicality. From interviewing registrars three main themes emerged:
1) frustrations arising from interruptions and distractions,
2) perceived lack of understanding and respect for radiology, and
3) the importance of community to a radiology working environment.

This allowed me to gain an understanding of the existing radiology workspace. By applying frames and imagining futures, different possible solutions came to the forefront. Out of this the most prominent overarching thought is to create a waiting room for physicians, and appoint first and second-year registrars as liaisons to assist with non-imaging-related tasks, such as answering phones and triaging incoming queries and requests. Formulating hypotheses of possible solutions was the third and final objective of this chapter, which has been achieved. Conclusions regarding these solutions are more tentative than would have been ideal, since there was no way to fully implement them. This will be undertaken in a further study after the conclusion of this thesis.

By achieving all three objectives, the aim of this chapter, namely to investigate how human-centered design can improve radiology environments in public hospitals in South Africa has been met. Next steps would be to go back to registrars with the solutions and workshop them practically, which unfortunately falls outside of the scope of this thesis. The next and final chapter serves as a synopsis of previous chapters, reiterating how each has achieved their aims and objectives, and highlighting original contributions to the field of academic design research.

CHAPTER FIVE
CONCLUSION

5.1 Summary of the chapters

This thesis has explored how human-centered design can be used as a means to improve radiology environments in public hospitals in South Africa, specifically Universitas Academic Hospital in Bloemfontein. In Chapter One the aims of the study were introduced, together with some background information around human-centered design in healthcare. A literature review was also performed examining previous research that has been conducted on the topic of human-centered design in the context of South Africa, and design problems.

Chapter Two focused on human-centered design in order to gain a thorough understanding of it as a philosophy. It traces its earliest origins back to Plato's *Republic* in ancient Greece, where citizens were invited to participate in community decision-making. Arnold (1959) introduces the term "creative engineering" – a precursor to what is known as modern day "design thinking" – a term discussed in detail in Chapter Three.

There are numerous benefits to the use of human-centered design. According to the International Organisation for Standardisation (ISO 9241-210:2010) it has substantial economic and social benefits, like increasing productivity and operational efficiency, reducing training costs by being easier to understand and use, and increasing accessibility for differently-abled people and those with disabilities. Furthermore, it improves user experience (in the case of digital interfaces), reduces stress and discomfort, provides a competitive advantage, and contributes towards sustainability objectives.

Limitations of human-centered design include the fact that it is not considered a tool for understanding and studying people's needs, nor as a means for controlling product development. Rather, it is intended to spark ideas and let people influence the research process and shape the outcomes of that process. There are also risks to blindly implementing what people request or reject, so the level of expertise of the problem solver is important to note. This is discussed in detail in Chapter Three. Another criticism is that human-centered design has the potential to be a "top-down" approach - since the designers involved determine the process that is followed and who is invited to participate and give feedback.

Human-centered design is sometimes utilised as a business strategy in what I term "design for business' sake". It can become a product or a business process, instead of being regarded as something of real value extending beyond the corporate bottom line. Design can also be utilised for design's sake,

and actually cause harm in communities. This happens when designs are created and even implemented without considering the complexities of any situation or even of any solution – this is illustrated in the *PlayPumps* example.

Lastly, another potential limitation of human-centered design is that it can be considered anthropocentric in a negative sense. The very name, *human*-centered design points to this. Firstly, we should ask whether humans should always be at the centre of a solution. And secondly, if the answer is yes, which humans should be centred in the solution? All of this fulfils the first research objective, which is to understand the broader philosophy of human-centered design, especially in terms of how it developed.

The second research objective is to compare different design approaches and consider advantages and limitations of each. This is done by means of a literature review and an analysis. Various approaches are mapped out by Sanders and Stappers (2008), and Steen (2011) builds on this diagram to map the approaches against two main axes that represent different tensions. Nine approaches are discussed in detail, each of which is arguably a possibility under the general intention of human centered design.

The third research objective of this thesis has been to understand how human-centered design has been applied to healthcare in general, as well as in a South African context. This is highlighted in the literature review and analysis in Chapter Two. To conclude Chapter Two a table lists the advantages and limitations of each of the different approaches, along with authors writing on each approach. This has not been found in literature to date, and is a novel contribution of this thesis.

Chapter Three investigated problem spaces, design thinking, and design processes. The aim of the chapter is to develop a framework underpinned by human-centered design for a South African radiology context. To this end there are two objectives to be met. The first is to explore and compare existing frameworks. This is done by means of a literature review and analysis.

Firstly, design problems are investigated in order to gain an understanding of their structure. I consider that the well-structuredness of a problem might be intrinsically linked to the problem-solver themselves, and consider the problem-solver as an agent of change (Dorst 2003; 2015). Next *problem spaces* are investigated, as one cannot presuppose that there is a set "design problem" at any one point in the design process. This is considered the *undetermination* of design problems. This leads to wicked problems being investigated as they relate to design problems and design problem spaces. Buchanan argues that most of the problems faced by designers are wicked problems, as design does not have subject matter besides what a designer considers it to be.

Nine practical frameworks or processes for approaching design problems are then discussed. The main framework used in this thesis is that of Dorst's Reframing, with parts of the other processes included where appropriate. Hereafter an overview of all practical processes for approaching design problem spaces is established, and the processes are compared to one another in the matter of how the steps relate to one another. This reveals many similarities, and also highlights the differences that are novel.

The main critique of most of the approaches is that their visualisations attempt to make the design process look neat and linear, when in reality it is far from this. Many of the processes seem to be aimed at non-designers, or junior designers just starting out in the design industry. These are people who need guidance and structure when it comes to following design processes. Considering the previous conversation regarding how the problem-solvers themselves influence the design problem that is established, concerns are raised that the design problem may be improperly implemented, or why certain necessary processes may not be thoroughly understood. The design processes that are put forward also do not consider which approaches they will be situated within, and leave no space for this vital aspect.

I argue that this is a process of 'democratising' design which is in fact diluting the design practice. It is easier than ever, with no formal training, to use existing templates to 'design' anything from interfaces to print material to logos. Processes such as the ones examined in Chapter Two make design accessible so that non-designers can perform these actions. To some extent this can be beneficial, as it allows non-designers to understand and to take part in the design process in instances such as participatory design and co-design. However, it leads to the risk that people may think they no longer need experienced designers, and therefore lose the problem-solving capabilities of experienced designers.

As a conclusion to Chapter Three, the design framework for this thesis is constructed. This is the second objective for this chapter: crafting a framework for this specific problem arena. It uses Dorst's Reframing concept as the main scaffolding, and slots in other concepts where appropriate to build a six-step process with divergent and convergent steps. It is named the design thinking reframing design process, as can be seen in Figure 44 and is underpinned by a human-centered design philosophy. The full process discussed in detail can be found on page 106. As both of the objectives for this chapter have been met, the aim has been achieved. This design process is iterative, and parts can be repeated in whatever order is deemed appropriate.

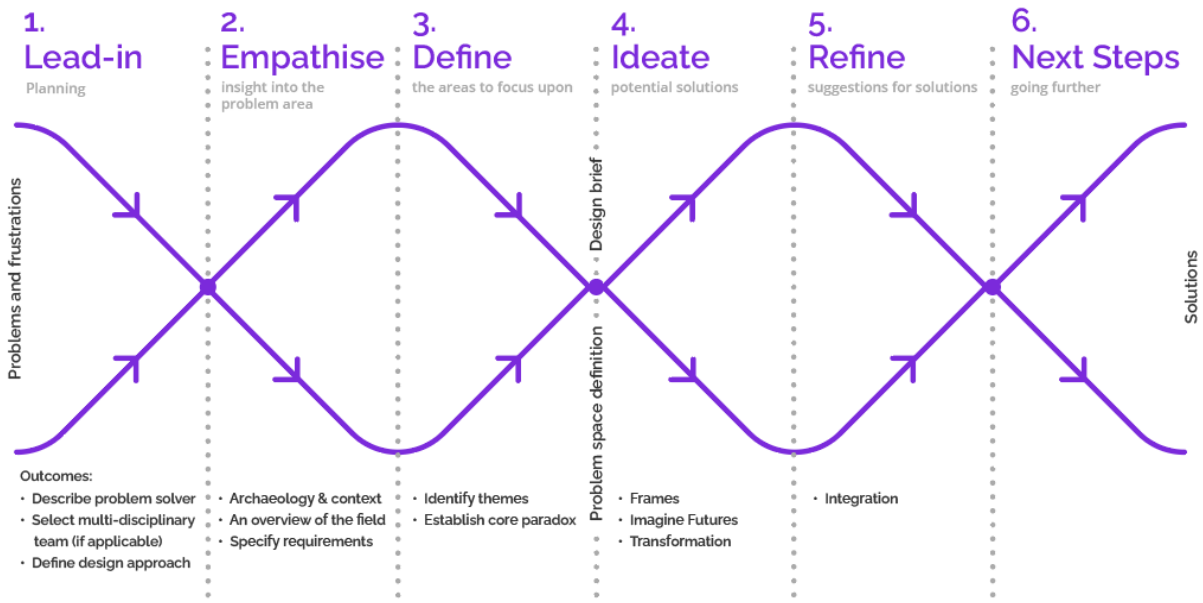

Figure 44: Design thinking reframing process. Diagram by the author 2022.

The case study that this thesis has been building to, is discussed and unpacked in Chapter Four. This is the third and final aim of this thesis, namely, investigating how human-centered design can be used to improve radiology environments in public hospitals in South Africa. To this end, the first objective of this chapter is to apply the design framework as defined in Chapter Three to the problem area.

By doing so, I note that the process as set out and the process actually followed are not the same. In reality, the process jumps between different sections, and numerous sections are repeated. It was noted that this was likely to happen, but visualising the actual process confirms the expectation. This again highlights the discussion in Chapter Three that the visualisations of design processes do not reflect reality – they merely serve as a vehicle to make the design process more understandable and easier to navigate for non-designers. I also note that the design process that was followed and the process that is written in the thesis are not chronologically the same. For the sake of brevity and flow of information some of the parts of the process have been merged and are discussed as one, although the processes were followed separately.

The case study is conducted according to the steps laid out in Figure 44, and the three overarching themes that arise from interviews with registrars are (1) frustrations arising from interruptions and distractions, (2) perceived lack of understanding and respect for radiology, and (3) the importance of community to a radiology working environment.

Hereafter the core paradoxes are established on page 143, and solutions formulated. The specifics of the hypothetical solutions are elaborated on below.

- **Self-help ticketing system**

  This system is initially conceptualised as a tablet with which physicians can book time with registrars, or notify them that they would like to speak to them, either via phone or in-person.
- **Introduce a physician liaison for attending to non-image-interpretive tasks (NITs)**

  By assigning first- and second-year registrars as physician liaisons to interact with physicians, pressure of NITs from more senior registrars will be alleviated, allowing the latter to concentrate on IITs instead.
- **Prioritising disruptions**

  Both the ticketing system and the physician liaison will assist registrars in prioritising disruptions.
- **Introduce a physician's consultation room**

  By introducing a dedicated room where physicians are welcomed. This allows for an area away from registrars' reporting area where they can focus on consultations with physicians.
    - **QR code screensavers**

      While waiting, physicians can scan QR codes to access articles relevant to their field in the context of radiology. They can either read the articles while they wait, or opt to read these later, as these can be stored on their phones.
    - **Radiology workstation for visiting physicians**

      There is already a workstation for visiting physicians, but it has been noted that this is rarely used. By placing it in the room dedicated to physicians, it becomes more accessible.
    - **Table, chairs and screen for consultations**

      Interdepartmental consultations regularly occur, and this will allocate a dedicated space for these meetings, complete with a workstation where cases can be checked.
    - **Introduce a drinks station**

      Considering registrars' passion for coffee, it can be a great way to share some of their team spirit with other departments.
- **Introduce a rotation for registrars to attend physician patient rounds**

  As explored by Malmouk *et al* (2013) and Aripoli *et al* (2016), "radiology rounds" can be introduced to give the departments more exposure to one another. This can serve to imbue physicians and registrars with a better understanding of what the other specialities do, and thus generate empathy and understanding.
- **Introduce workshops and seminars on nonviolent communication**

  Since conflict in healthcare settings has been shown to be quite prominent, the department can be proactive in teaching their registrars empathic communication skills, which can assist in making it easier to communicate with other departments.

The next step is to consider how the new frames will fit into the broader organisational context, for *integration*. The possible effects of the hypothetical solutions are discussed, which include an improvement in inter-departmental camaraderie, communication and a lessening of frustrations by allowing registrars to have more dedicated focus time.

Phase six, *next steps*, discusses what the effects of this research framework and this thesis will be. The first priority is to send the proposed solutions to the department of diagnostic radiology at Universitas Academic Hospital, specifically Professor Janse Van Rensburg, as well as all of the registrars who have participated in the study. Ideally workshops would be held to get feedback on the proposed solutions, in order to customise them for the registrars' environment. Once this has occurred, the suggestions can be distributed to other institutions, or possibly the process repeated to get specialised solutions for other situations.

This thesis has explored human-centered design as a means to improving radiology environments in public hospitals in South Africa , and by meeting each of the research objectives, the aim of this thesis has been achieved.

5.2 Contributions of study

This study has explored various areas that thus far have not been researched in detail. One such area was the investigation of the advantages and limitations of various human-centered design approaches. This has been done in depth, including assessments of examples where the approaches have been used in a South African context, as well as in a healthcare context. No similar comparison of the advantages and limitations of different human-centered design approaches has been found in academic literature.

This study has also critically analysed and compared various design thinking processes, which have not been subjected to any meaningful research in an academic sense. By viewing each process through the lens of what would advance the human-centered design intention, aspects of the different approaches were combined to form a new design thinking reframing process. This new process is purpose-built for the South African healthcare field by always placing the human who is being designed for at the centre of the solution. The process has been applied to a real environments, in this case, the diagnostic radiology department at Universitas Academic Hospital in Bloemfontein. This study unearths valuable insights into the working environments for radiology registrars in a public hospital, and the framework is used to come up with hypothetical solutions for their context. This exploration of the landscape of human-centered design in the South African healthcare industry has not been done previously.

5.3 Limitations of study and suggestions for further research

While an effort was made to interview as many registrars at the diagnostic radiology department at Universitas Academic Hospital as possible, only those who responded to the request for an interview were interviewed – seven out of ten responded. Consultants were not interviewed (they were not asked), nor was the Head of Department due to his unavailability. Other physicians in the hospital were also not asked for their considerations regarding the radiology department.

While the registrars give valuable insights covering a wide variety of topics, there are undoubtedly many more opinions and insights that this study did not manage to glean due to time constraints, as well as lack of interest to participate in the study.

As has been discussed in detail throughout the thesis,[74] the ongoing Covid-19 pandemic created a significant limitation for the study. This was both in terms of time and availability of the registrars and radiologists, as well as in terms of methods that could be used. For instance, diary studies were deemed too intensive, and contextual inquiries were not possible due to the University of the Free State requiring all research to be conducted virtually as far as possible. I could not obtain ethical clearance to be on-site with the registrars. Instead I carefully considered research that had been conducted on the various topics raised by registrars, to gain insights.

Throughout the thesis there are a few topics that have been mentioned as worthwhile themes for further research. The suggestions for solutions will be presented to the Head of Department as well as registrars once this thesis is finalised, with the aim of discussing the feasibility of implementing these solutions. This will be done after this thesis is concluded, as discussed in Chapter Three.[75]

A study can be conducted to ascertain registrars' and physicians' perceptions of inter-departmental working conditions before and after the implementation.

Studies may also be conducted at other radiology departments to see if the same solutions work in other places, or if the same frustrations are evident in other healthcare spaces.

Considering the prominence of interdepartmental relationships and friction in the themes that emerged from the research, it would be useful to conduct a study with other clinicians in the hospital to understand their view of radiologists and see how better they can work together. Some research[76]

[74] On pages 35 and 40.
[75] Page 83.
[76] As discussed in Chapter Four, pages 138 – 144.

has been conducted on conflict resolution in hospitals and healthcare spaces, but effective ways of working together can still be investigated further.

One area that has not been focused on too much in this thesis is the impact of the software that registrars and radiologists work on, and how these different platforms interact with one another. As noted by Gualtieri (UX Healthcare 2020) most radiology software systems are created in the western world, with little to no consideration how these systems are used in reality in developing countries. In 2019 Universitas Academic Hospital was still running Windows 7 on some of their computers. The reason for this was the radiology software they used was old and would not work on a newer operating system. Registrars also made numerous mentions of frustrations relating to the FUJI PACS system they use. It would be valuable to understand how information design and user experience design (UX) can be used to improve radiology workflows between the different software used. This can range from picture archiving and communication systems (PACS) and electronic health records to dictation software. This is a crucial part of radiologists' and registrars' working experience. It would be interesting to understand what an ideal PACS and a workstation for a South African context would look like and entail.

Moving away from healthcare, another area to explore further is the democratisation of design. Is it beneficial to have non-designers understand design processes, or is it undermining designers by making processes seem over-simplified and easy?

Lastly, the question of the axiological and philosophical basis for human-centered design is an area that asks for further research.

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APPENDIX A: Letter of informed consent, 2020.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Humanities 100.
1919 - 2019
School of the Arts

LETTER OF INFORMED CONSENT

Invitation to participate in a Research Study

I would like to extend an invitation to participate in a qualitative research study entitled **An exploration of human-centered design as a means to improve radiology environments in public hospitals in South Africa**. This study forms part of the requirements for the PhD Degree in Information Design for which I am currently registered at the University of Pretoria.

One aim of the study is to investigate and understand the daily working environments of radiology registrars and radiologists in public hospitals in South Africa. Proposed solutions to any issue and problems will be developed using a human-centered design approach. Human-centered design seeks to place people at the heart of understanding systems and creating potential solutions, and aims to work with people in their own contexts to design systems that improve human knowledge and functioning

Participant selection

You are being invited to take part in this research because your experience as a registrar or radiologist can contribute much to our understanding and knowledge of radiology practises in local public and private hospitals.

Research methods

- The research will involve your participation in a virtual face-to-face informal **interview** or conversation that will take about an hour,
- You will also be asked to **keep a notebook** of your everyday working experiences for a two-week time period: to be confirmed based on your availability. The intention is to gain an understanding of your daily working environment: routines, habits, needs, frustrations, inspirations, etc.

It is envisioned that these informal interviews/conversations will take place between January and June 2021.

Confidentiality

Information arising from these interviews/conversations is to be used in the writing of my thesis. Virtual sessions will be video-recorded, and the researcher and her supervisor will have access to the recording. The interviews/conversations will involve no risks or discomfort to you. The interviews/conversations are solely for research purposes, and not for any form of personal gain.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and your identity will not be disclosed. There will be no financial gains for you as participant or for myself as researcher.

Your participation is voluntary and you may withdraw from participation in the study at any time, without any negative consequences. The data collected for this study will be stored in electronic format at the School of the Arts (UP) for 15 years.

Anonymity
Anonymity is assured for registrars to encourage open and candid communication, without any fear of repercussion or potential negative impact to their careers or reputations.

Qualified radiologists may choose whether they would like their names revealed in the thesis. If not, confidentiality is assured; in the writing of the thesis, your name would be replaced by a pseudonym. You are free to contact me should you wish to clarify any issue.

The study will take place only in accordance with the approvals of the School of the Arts at the University of Pretoria, as well as the Ethics Committee of the Faculty of the Humanities, and the Ethics Committee of the University of the Free State. If you have any questions or concerns about being a participant in this study, you may contact me either by email or telephone, listed below.

Thank you for your consideration.

Yours sincerely,

Lizette Spangenberg
Principal researcher
Cell: 072 1322 188
Email: Lizz_s2@hotmail.com

Prof Duncan Reyburn
Supervisor
Office: 012 420 2353 / 5189
Email: duncan.reyburn@up.ac.za

Charné Vercueil
UFS Ethics Committee Contact Person
Office: 051 401 7083
Email: vercueilcc@ufs.ac.za

STATEMENTS OF CONSENT BY PARTICIPANTS

I _____, agree to participate in this research study: '**An exploration of human-centered design as a means to improve radiology environments in public hospitals in South Africa**'. I am aware of the terms and conditions regarding my participation in this research study, as outlined in the letter of invitation handed to me. Accordingly, I know what I will have to do and that I can stop at any time should I wish to.

_____ _____

Signature of participant Date

APPENDIX B: Signed letter of permission from Professor Janse van Rensburg, 2020.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Humanities 100.
1919 - 2019
School of the Arts

8 June 2020

Permission to Conduct Research Study

Dear Dr Janse van Rensburg,

I am writing to request permission to conduct a research study at the diagnostic radiology department at the University of the Free State. I am currently enrolled in the Information Design postgraduate degree at University of Pretoria, and am in the process of writing my PhD thesis. The study is entitled '**An exploration of human-centered design as a means to improve radiology environments in public hospitals in South Africa**'.

My hope is that the hospital and university administration will allow me to engage with radiology registrars and radiologists working at Universitas Academic Hospital. Doctors who volunteer to participate will be given consent forms to be signed and returned to the primary researcher.

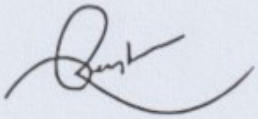
If approval is granted, participants will be asked to engage in interviews, focus group discussions, and a journal-keeping exercise. This is explained in more detail in my preliminary PhD proposal which is attached. This study still has to be ratified by the ethics committee of the Faculty of Humanities.

Your allowing me to conduct this study will be greatly appreciated. I will follow up with a telephone call next week and would be happy to answer any questions or concerns that you may have at that time. You may also contact me at my email address below.

If you agree, kindly sign below and return the letter via email. Alternatively, kindly submit a signed letter of permission on your institution's letterhead acknowledging your consent and permission for me to conduct this survey/study at your institution.

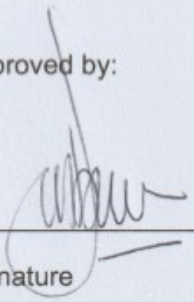
Sincerely,

Lizette Spangenberg
Principal researcher
Cell: 072 1322 188
Email: lizette.spangenberg@gmail.com



Prof Duncan Reyburn
Supervisor
Office: 012 420 2353 / 5189
Email: duncan.reyburn@up.ac.za

Approved by:



Signature

18 JUNE 2020

Date

DR J JANSE VAN RENSBURG (HOD: RADIOLOGY)

Print your name and title here

APPENDIX C: Examples of interview questions, 2020.

What made you choose to specialise in radiology?

What do you enjoy most about working in radiology?

What do you dislike most about working in radiology?

What does your typical day look like?

What is the first thing you do when you get to the hospital/department?

What is the first thing you do when you get to your workstation?

What is the first thing you do when you need to open a patient record?

What systems/programmes do you use at the moment to view X-rays, CT scans and MRI scans?

How do you feel about the systems that you use?

What do you like about your working environment?

What do you dislike about your working environment?

What frustrates you about your working environment?

What are in your opinion the most important features of a radiology work-environment?

What is your biggest frustration at work?

Is there anything you wish you could change?

How do you feel about working in a public hospital?

What do you think is different about working in a public hospital vs working in private practice?

Do you plan on staying in public practice or going into private practice when you graduate? Why?

What are the most important things when working in the radiology department?

How has Covid affected the way you work?