Investigating the impact of human-centric public transport design principles on the desirability and operational success of public transport in the Gauteng Province, South Africa: a mixed-methods study

By

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Thesis presented in fulfilment of the requirements for the degree of Master of Engineering in Civil Engineering in the Faculty of Engineering at Stellenbosch University

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April 2022

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Abstract

South African commuters are continuously disappointed by the provision of unsafe, unreliable transport services, feeling transport authorities and modal operators remain indifferent towards their needs and complaints. Because their core travel needs are disregarded, frustrated commuters may no longer feel the need to support public transport (PT) development in South Africa, causing customer's loyalty to PT to plummet while expressing their frustrations at transport infrastructure locations.

Given these concerns, there exists a need to ethically provide for the travel needs of captive lower-income commuters in South Africa by establishing a transport culture more focused in making human needs the centre of PT design. Thus, the study begins with the hypothesis that the PT industry in the Gauteng Province of South Africa could be more operationally successful and desirable to commuters if it incorporates human-centric design (HCD) principles into its fundamental planning and development.

A Pearson Correlation Coefficient of **r = 0.982** was determined in this study, demonstrating that the incorporation of more HCD measures into Gauteng's PT service provision will indeed result in increased commuter satisfaction and in turn improve the service quality and thus operational success of these services. The study provides a set of five human-centric public transport design (HCPTD) principles that are capable of enhancing customer satisfaction and providing commuters with an opportunity to participate in Gauteng PT design by regularly considering their views, feedback and concerns. In addition, these principles provide a platform for public engagement and act as a mechanism for the voices of customers to be heard and incorporated into PT design.

A directly proportional relationship was proven between the perception of a Gauteng PT service, the desire to use the service and the value commuters placed on the service. Therefore, if Gauteng PT authorities aim to encourage more commuters to make use of PT services and obtain increased funds from these services, utilising the HCPTD principles is key to increasing customer satisfaction and desirability for these services. In order to improve the perceived value of a PT service, Gauteng PT services must be (in order of importance) made safer and more secure, more reliable, more cost-effective and increasingly available and accessible.

Furthermore, it was found that proper enforcement and regulation of the MBT industry is necessary in the GP in order for its PT systems to become more developed and promote modal network integration. Only by resolving issues relating to the MBT industry can the demand for transport can be more freely distributed across the different kinds of transport, likely offering a change in the transport system where taxis have a different role to play. The taxi industry also needs more exposure, training and understanding of business moving forward in order to form part of the upcoming integrated PT system.

Acknowledgments

I express huge gratitude to my study advisor, Professor MD Sinclair, for the patience, clear guidance and brilliant advice that you provided me with throughout this study. Thank you for your willingness to meet up with me regularly when I was struggling, stressed and not sure how to continue – your guidance and softness was invaluable to the direction of my study and gave me the motivation to keep going no matter what obstacles I faced, or how overwhelmed I was.

Another individual who I could not go without throughout this complex, unfamiliar study was my mother, Dr MB Wolfswinkel: a devoted, tenacious and passionate academic who just achieved a *Cum Laude* for her Master's degree. I thank you so much for your innovative idea that sparked the derivation of my research topic and thus the evolution of my Master's research study. Being able to bring my endless concerns and questions to you to converse about and reach solid, clear conclusions meant the world to me, and it was something I could not go without. This degree has been the biggest challenge of my life so far, and your involvement, brilliant mind, patience and passion for academia carried me through to finishing it.

Next, I would like to acknowledge the six experts that I interviewed for Phase 1 of my study. Even with a full schedule and other priorities, you agreed to having an interview with me and helping me with my research study, without wanting anything in return. The insights you provided in these interviews formed the bedrock of my Phase 2 research and were incredibly meaningful to improving the quality, reliability and desirability of Gauteng PT services. Thank you for taking the time to converse and share your valuable experience with me so that I could utilise these understandings to contribute to my field's research.

Lastly, I would like to express my gratitude to my dearest friends, father and data collection assistant for standing by my side, enquiring curiously about the progress made in my study and always being there for me. You played a key role in keeping my spirits high and helping me stay focused and passionate about the complex research I was busy with. I appreciate you and am so grateful for your love, assistance and support.

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List of Abbreviations

PT: Public Transport

HCD: Human-centric design

BRT: Bus Rapid Transport

MBT: Minibus taxi

NMT: Non-motorised transport

MaaS: Mobility-as-a-Service

ITS: Intelligent Transport System

DoT: Department of Transport

HCPTD: Human-centric public transport design

DCA: Data collection assistant

GP: Gauteng Province

MOE: Margin of Error

LOC: Level of Confidence

PPP: Public-Private Partnerships

LOS: Level of Service

DCS: Data Collection Scenario

GHS: General Household Survey

SES: Sequential Exploratory Strategy

IC: Inclusion Criteria

EC: Exclusion Criteria

UD: Universal Design

Chapter 1 Introduction

1.1 Introduction

South Africa has come very far since the Apartheid era and has made big strides in its socio-economic development as a developing country. However, many South African commuters are still forced to endure unsafe, unreliable and inconvenient PT services, depending on the system to deliver them to their destinations but often being disappointed by the consequences of its poor management and fragmented service provision.

Commuters in South Africa rely on a variety of PT modes every day to access various social and economic opportunities such as the workplace, academic institutions and healthcare (Mthimkulu, 2015). Indeed, PT services were originally designed to provide transport for labourers from suburbs and low-income settlements to workplaces situated in central areas (Khosa, 1995; Lombard & Coetzer, 2007). The South African Department of Transport stands by values such as fairness, quality, transparency, accessibility and affordability in their transport service provision, (Department of Transport (RSA), 2019), prioritising the development of PT as it is the best solution to mobility in highly populated locations (Futshane & Wosiyana, 2005).

However, how much evidence is there of actually *implementing* these objectives for the betterment of South African commuters? Furthermore, can centralising the needs, desires and feedback of South African commuters resolve these issues and give commuters the travel service they expect and desire?

1.2 Background

For many years, South African commuters have placed their faith and financial investments into the government with the hope that safe, reliable and affordable travel services would result (Lombard and Hugo, 2002). Many promising strategies are introduced by the Department of Transport (DoT) to create a cohesive, inclusive transport system, yet the plans are not implemented or done so unethically due to financial or political reasons. Case studies of the Gautrain project (Thomas, 2016) and Moloto Rail Corridor Development project (Mabhena, 2019) illustrate these insights. The potential of South Africa's developing PT system thus remains diluted by this lack of synergistic leadership, given that political will is often out of sync with the requirements of transportation policies and plans (Mthimkulu, 2015). Often, solutions being implemented fail to address the actual problems needing attention (Oxford, 2016), while the consequences of a lack of modal integration challenge the incorporation of viable transport plans (Shaw, 2006). These unaddressed issues continue to limit the capabilities of the desired collaborative, seamless PT system, whom many rely on to earn an income.

As a result, South Africa's PT system is falling short of performing as it is required to fulfil the travel needs of their customer base, likely because customer service has not been a priority (Lombard & Coetzer, 2007). Captive, reliant commuters have been disappointed on countless occasions by unsafe, unreliable transport services and feel transport authorities and modal operators remain indifferent towards their needs and complaints (Lombard & Hugo, 2002). It seems the faith that commuters have in their government's capabilities has deteriorated over the years, meaning transport infrastructure locations have become and remained the site where many fed-up commuters express their frustrations and make their voices heard (Khosa, 1995).

1.3 Problem statement

Today, the South African transport industry is grappling with the resentful hearts and minds of their PT customer base and attempt to introduce innovative, improved transport services to meet their people's travel needs. However, the government seems to have lost the respect and support of the people, so these improvements are constantly rejected with strikes and destructive behaviour, regardless of how sophisticated or inclusive they may be. Frustrated commuters like those interviewed in Lombard and Hugo (2002) may no longer feel the need to support PT development in South Africa due to the inconsistent quality of PT service provision and their travel needs being disregarded, causing customer's loyalty to PT to plummet.

Seeing as no other viable travel alternatives are available, this lack of loyalty to PT services has induced an over-dependency on private transportation that densifies road congestion and leads to unacceptably high rates of road accidents (Mthimkulu, 2015; Banister, 2005; Říha & Tichý, 2015); carbon emissions and the deterioration of the roads pose further environmental and financial risks (Banister, 2005; Gnap et al., 2006). South African travellers have also resorted to behaving spitefully by destroying valuable transport infrastructure, like when commuters and stakeholders from other travel modes burnt brand-new rail rolling stock and equipment to the value of over R520 million between 2015 and 2019 (Geach, 2019). Imagine where this sort of capital could have been invested in South Africa's economy if a mutual, transparent and respectful relationship existed between the government and its people.

This theme of disrespect and conflict has also manifested in the behaviour of transport service operators like minibus taxis (MBTs), who seem to focus on maintaining ownership over a selected group of reliant passengers and maximising their earnings (Shaw, 2006; Lombard & Hugo, 2002), when in fact the needs of their dependent passengers should be prioritised. Furthermore, control over modal competition has not been properly regulated (Shaw, 2006), so decisions to maximise customer turnover are often made at the expense of modes in the network (Fourie, 2003; Walters, 2014; Mthimkulu, 2015). This undermines the unique contribution of each mode in the network and the specific role they have been assigned to play

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(Department of Transport, 1998), in turn affecting the balance of modes in the PT system and the distribution of passengers and earnings (Mthimkulu, 2015).

Therefore, it is made clear that a damaging cycle exists between the disrespect commuters and service operators have of the South African government and the consequences of increased private automobile usage and PT infrastructure destruction. There exists a need to permanently close this cycle, by more ethically providing for the travel demands of captive lower-income commuters and establishing a transport culture that is based in making human needs the centre of design thinking. That way, commuters and operators can again begin to trust in the capabilities and actions of the South African government and grow in respect and support, so that an inclusive, fair and integrated transport system may prevail.

1.4 Research aim

1.4.1 Introduction

Commuters complain that modal operators are only interested in earning income over and above their service's high operating subsidies, thus remaining indifferent towards their personal travel needs and complaints (Lombard & Hugo, 2002). Having little to no other travel alternatives to choose from in their present circumstances, these passengers are unfortunately held captive by the unsafe, unreliable transport that is offered by these transport services, excluded by either the affordability or difficulty in accessing these services (Lombard & Hugo, 2002; Barrett, 2004).

Arguably, many dependent labourers have lost faith in the potential of South Africa's transport system after being repeatedly disappointed over the years, causing them to start resenting their government for not taking the necessary action to satisfy their expectations. This could potentially be one reason that commuters at times resort to aggressive behaviour to make their voices heard. Considering the detrimental competitive behaviour between modes to maximise profits and the views posed by commuters, the researcher begins with the assumption that the reason South Africa has been unsuccessful in improving the quality of its PT services results from a lack of human-centric design (HCD) focus.

However, by placing the needs, complaints and suggestions of these commuters at the centre of transportation decision making, South African transport authorities would be able to directly incorporate these insights into the design and development of PT services. This would clarify the travel needs of these stakeholders and ensure they are more effectively provided for, cultivating a positive mindset towards PT services in South Africa and increasing the likelihood of gaining the respect, support and trust of commuters. If more people feel encouraged to join the network because it accommodates their basic travel needs, South African transport authorities would be more equipped with the social and financial support they need to understand the needs of their customer base and provide higher quality travel services.

1.4.2 Defining the research aim

In order for commuter needs and perceptions to become the centre of transport decision making in South Africa, it can be argued that the design of existing PT strategies and services must be adjusted to follow more human-centric thinking. Therefore, the main aim of this study is to offer a set of **three to five human-centric PT design (HCPTD) principles** that have been proven to work effectively in promoting elevated customer satisfaction, desirability to use PT as well as improved service quality and operational success of PT in the Gauteng Province, South Africa.

These principles would be the most relevant to Gauteng PT users and the services they use, providing a platform for public engagement and acting as a mechanism for the voices of customers to be heard and incorporated into PT design. The study's findings thus aim to equip transport authorities and modal service operators in South Africa with the knowledge necessary to incorporate HCD into their PT service provision based on the views of Gauteng commuters who use these services regularly.

1.5 Research objectives

1.5.1 Guidance from literature

Research objectives decompose the research aim into various segments that are solved individually, thus constructing simplified steps describing how the research aim is achieved. These steps explain how the questions posed in the study are answered by defining *what* is being studied, *when* they should be answered, *who* is conducting the research, *why* the research is being conducted and *how* the research will answer these questions (Future Learn, 2020; Business Research Methodology, 2019).

Research objectives outline exactly what the researcher would like to achieve in the study, thus guiding the intention and execution of the research. To create an apt objective, the topic of interest should be studied in great detail to highlight the missing links in understanding, indicating where research is still required (Editage Insights, 2019). Furthermore, according to Lyons (2017), successful objectives should be laid out in a "logical sequence" and defined using active, "operational" terms to ensure that the progress in achieving the objectives can be assessed or quantified (Lyons, 2017).

Objectives are also statements that indicate how a construct or parameter in a study can be quantified, also providing guidance as to how the research questions can be answered or research hypotheses tested (Jaikumar, 2018). All research objectives should follow **SMART** specifications (Future Learn, 2020), standing for:

- **S**pecific – objectives should be precise and clearly defined
- **M**easurable – what proof is there that the objective has been achieved?

- **A**chievable – what can the researcher be expected to achieve in the timeframe?
- **R**ealistic – does the researcher have the necessary resources to meet the objective?
- **T**ime-constrained – by when must the objective be completed/achieved?

1.5.2 Research objectives for the study

The following research objectives are defined to operationalise the achievement of the research aim. These objectives inform and guide the decisions made in the study's research design.

1.5.2.1 Research objective A

Describe the measures currently being taken to apply human-centric thinking to PT design in Gauteng, as well as which measures are required for Gauteng PT services to adopt more human-centric thinking. These measures include the strategies currently being applied by Gauteng transport authorities to understand and provide for the core needs of commuters, HCD aspects that are in demand in Gauteng's PT services and the design principles that can prove successful when applied to the Gauteng's unique context.

1.5.2.2 Research objective B

Evaluate the extent to which commuters' level of dissatisfaction with Gauteng PT services are related to a lack of HCD measures in PT provision. If this is not the only reason commuters are dissatisfied, clarify which other factors play a role in commuters being unhappy with these services and whether incorporating human-centric elements into Gauteng PT design would be more capable of meeting their travel needs.

1.5.2.3 Research objective C

Fully develop three to five HCPTD principles which can be applied to Gauteng's PT design to promote elevated customer satisfaction as well as improve the service quality and operational success of these services. This set of principles are developed from primary research findings and literature. Furthermore, this set of principles comprises the final product of this study.

1.5.2.4 Research objective D

Provide Gauteng transport authorities and service providers with general guidance on how to adopt more human-centric thinking and incorporate the final HCPTD principles into their PT service design. The significance of these principles to the development and operational success of Gauteng's PT system should be clarified and discussed based on the study's findings.

1.6 Research questions

1.6.1 Guidance from literature

Birthed from the research problem, research questions are the central questions asked in a study, stating what the researcher is attempting to discover in the study. Furthermore, it states how the researcher intends to find solutions to the knowledge gap illuminated in the research problem and close this gap through applying themselves to research (Foss & Waters, 2020; Business Research Methodology, 2019). Research questions guide the procedure followed in the study and are reflected in the title of the study, their extent informed by both the research aim and research objectives (Foss & Waters, 2020; Future Learn, 2020). This is known to be the most important component of the study, requiring the greatest attention to detail to define clearly (Foss & Waters, 2020). Ultimately, the research questions are answered by the findings of the study (Business Research Methodology, 2019).

Indeed Editorial Team (2021) suggests using the **FINER** criteria to develop high quality research questions, generally highlighting the vital aspects of the question to improve the likelihood of creating a successful research project. The FINER acronym stands for:

- **F**easible – does the researcher have the necessary experience, time or resources to answer the question? Considering the scope, is it possible to answer the question?
- **I**nteresting – will the answer to the question intrigue to the audience of this study?
- **N**ovel – does the question confirm, counter or interpolate previous findings?
- **E**thical **–** will members of a review board accept this question as ethical?
- **R**elevant – is the question relevant to the expansion of knowledge in the research field or future research?

1.6.2 Defining the research questions

The research questions proposed for this study are presented in Table 1. Given that the research questions are the most vital aspect of the study (Foss & Waters, 2020), a choice has been made to select and define each question in a sequential format, such that each question informs the next and in turn informs the approach followed in the research design.

Table 1: Research questions for the study

Research Question 1 (**RQ1**) - informs the *synthesis of literature*
Which principles of human-centric design (HCD) have been applied successfully to South Africa's PT system to improve the quality of transportation and satisfy commuters?
Research Question 2 (**RQ2**) - informs the *first phase* of field research
To what degree have South African transport authorities successfully accounted for human needs, preferences and complaints in the design of PT services?
Research Question 3 (**RQ3**) - informs the *second phase* of field research
To which extent are the levels of dissatisfaction of South African commuters with PT services related to a lack of HCD measures?
Research Question 4 (**RQ4**) - informs the *application of the study's findings* to South Africa's PT system
How can transport authorities and modal service operators in South Africa incorporate HCD principles into their PT service provision to effectively improve the quality of PT?
Research Question 5 (**RQ5**) - considers how the study's findings can *constructively serve the priorities of South African transport authorities*
How can this study contributing to current PT priorities in South Africa, such as mobility trends and network integration?

1.7 Research hypothesis

1.7.1 Definition

After the research questions are defined, they are often developed into one or more research hypotheses. These make an initial prediction related to the topic or phenomena of interest to assess whether a relationship indeed exists between the theoretical constructs identified. Hypotheses create the context that describes the type of data the study should collect and are stated in such a way that they can be tested. The suggested hypotheses can either be accepted or rejected based on the study's findings (Haynes, 2006; Foss & Waters, 2020).

1.7.2 Defining the study's research hypothesis

Informed by the research questions above, the primary research hypothesis for this study is as follows:

The South African PT industry could be more operationally successful and desirable to commuters if it incorporates HCD principles into its fundamental planning and development.

Chapter 2 Literature Review

2.1 Introduction

The content presented in this chapter of the study serves to inform the researcher of the study's main constructs, namely HCD and PT, and synthesise literature that can be used to guide and educate the researcher on subjects related to the study's topic. In addition, once data has been collected, the literature review can be used as a reliable framework to reinforce the study's findings and discuss these findings in context of concrete academic findings.

Given that this is a mixed-methods study that incorporates both qualitative (narrative) and quantitative (numerical) research approaches, this study's literature review begins by considering the context of both approaches, also defining and investigating the study's two main constructs: HCD and PT. Literature related to sampling design is then considered to guide the study's research design. The remainder of Chapter 2 considers the state of transportation in South Africa when this study commenced, challenges that limit sustainable transport development in South Africa and essential criteria for a user-centric transport environment to be created. The concept of network integration is also investigated given that the study aims to promote PT integration in Gauteng, considering the process of integration, benefits and considerations of such integration.

2.2 Research paradigm

2.2.1 Guidance from literature

A research paradigm can be described as an essential set of assumptions, beliefs and agreements shared by a community of researchers that influences how a researcher views the world and addresses problems (Given, 2008; Creswell, 2003). By stating which lens the researcher sees the world through, a clear indication of the research bias is provided, strengthening the credibility of a researcher's motives in research proposal defences. The selection of a research paradigm is central to a study's research design as it strongly impacts the definition of the research problem as well as the nature of the research question and the way it is studied (Albertyn, 2020). For this reason, choosing an apt research paradigm provides clear guidance on which research approaches, research methods and strategies are the most effective to study a given phenomenon from a researcher's unique scientific perspective (Denzin et al., 2005; Kuhn, 1962).

2.2.2 Selection of paradigm

Four research paradigms exist in which scientists can position themselves in their research, namely the Positivist, Interpretive, Participatory and Pragmatist (blend of Interpretive and Positivism) paradigms (Mingers & Wilcocks, 2004). After considering the definitions of all four paradigms, the Pragmatism paradigm was selected as the most apt in the context of this study and the researcher's thinking approach.

2.2.3 Understanding the paradigm

Initially, researchers in a Pragmatist paradigm identify the problem statement, clearly define it and contemplate the problem from many points of view, being guided by their own personal beliefs and experiences, the beliefs of the research field as well as the experiences of others (Dillon et al., 2000; Morgan, 2014). Instead of only obtaining knowledge through an objective or subjective mindset, pragmatists prefer to practise abductive reasoning in which knowledge is acquired over a spectrum of mindsets (Goles & Hirschheim, 2000; Goldkuhl, 2012; Morgan, 2007). Ultimately, one reality or research method is selected based on how effectively it manifests the desired outcomes or goals (Dillon et al., 2000; Tashakkori & Teddlie, 1998; Morgan, 2014).

Researchers in this paradigm should place a greater emphasis on the outcome of their research and the research questions proposed instead of the research methods used but should study both methodology and epistemology to gain a broad understanding of the research problem (Creswell & Clark, 2017; Morgan, 2007). Generally, *methodology* links philosophical problems to methods following a systematic approach and *epistemology* describes a set of beliefs affecting how research is conducted; research design helps in linking the research questions to the research methodology (Morgan, 2007; Morgan, 2014). A research design and methodology most suitable to addressing the research question should be selected (Goldkuhl, 2012; Morgan, 2007).

A variety of methods such as interviewing, literature synthesis and observation are applied in this paradigm to answer the proposed research questions, aiming to strengthen weaknesses in a particular field by applying a mixed methods approach (Patton, 2000; Johnson & Onwuegbuzie, 2004). Researchers confirm that pragmatism best satisfies the needs of a **mixed-methods study** that integrates both qualitative and quantitative data, explaining how different research approaches can be combined in a productive and successful manner (Morgan, 2014; Hoshmand, 2003). Due to its interwoven research approach, research from this paradigm yields both data and theories in order to better understand the research problem and answer the research questions (Goldkuhl, 2012; Morgan, 2007).

It is important to note, however, that the problem-oriented nature of the pragmatism paradigm may limit its ability to locate and investigate real world problems, arguably because it proposes problems only

applicable to a specific context (Thompson, 1996). Additionally, because of its contextual nature, the practicality and applicability of the research findings could run the risk of being vague and non-beneficial to the research community if its applicability is not clearly defined by the researcher (Johnson & Onwuegbuzie, 2004).

Pragmatism investigates the nature of a problem, potential solutions and their nature, as well as possible actions that can be taken via methodology (Morgan, 2014). Dewey (1933) offers a revised and summarised five-step model to understand problem solving in the pragmatism paradigm:

- **Step 1:** Researcher comes across an issue and defines it as a research problem
- **Step 2:** Researchers use their own beliefs to consider the problem more contextually and in-depth, likely revealing new insights into the problem that would help define more appropriate solutions.
- **Step 3:** Investigate various methods as strategies for addressing the research questions and creating an apt research design.
- **Step 4:** Reflect on these actions and, if necessary, follows several iterations of proposing a research design, selecting a method, pondering on the selection and redefining the research question.
- **Step 5:** Once the research- questions, methodology and design are confirmed, research is conducted using the methods suggested above.

2.3 Research approaches involved

2.3.1 Background

A Pragmatism research paradigm was selected for this study (see justification in section 3.2), implying that a *mixed-methods* (MM) research approach was followed in this study. According to Johnson and Onwuegbuzie (2004), the only way the aspects of qualitative and quantitative methods can be effectively combined is by studying the specific properties of both approaches. In addition, the goal of the MM research approach is to cultivate the strengths and mitigate the weaknesses of qualitative and quantitative approaches, integrating insights from each to produce a practical and apt solution (Johnson & Onwuegbuzie, 2004).

Therefore, this section investigates the general characteristics, advantages and disadvantages of qualitative, quantitative and MM research approaches, also investigating the presentation of their respective research designs, methodologies, data collection and data analysis. The objective of studying these specific traits is to clarify which aspects of one approach could be used to balance and reinforce aspects of the other approach to yield a sturdy, workable methodology and research design. Exploration into these approaches would also illuminate which research methods would be apt for collecting data in this study, in addition providing guidelines to aid the presentation of research and literature.

2.3.2 Qualitative research approach

2.3.2.1 *Description and characteristics*

The main definitive characteristics of the qualitative approach include the discovery of phenomenon, inductive reasoning to uncover unseen patterns and the formulation of new hypothesis and social theories (Johnson & Onwuegbuzie, 2004; Creswell, 2003; Leedy & Ormrod, 2005). Qualitative research comprises of five main strategies, namely case studies, ethnography studies, phenomenological studies, grounded theory and content analysis (Creswell, 2003).

2.3.2.2 *Methodology, research design, data collection and data synthesis*

Sensual data is collected by means of observation as well as studying how people interpret a specific social phenomenon from their perspective (Leedy & Ormrod, 2005; Creswell, 1994). Next, the information is reflected upon, interpreted and applied to explain these phenomena by applying inductive reasoning, in which the researcher infers valid insights and conclusions about a factor or situation, by evaluating the relationship between a person's perspective and their consequent behaviour (Williams, 2007).

2.3.2.3 *Benefits and drawbacks*

By using a preferred approach resonating with the research and its context, a qualitative approach is an apt strategy for exploring and describing a complex situation, as well as how and why it took place. Situations, conditions and the demands from people in a specific local context can be studied and observed effectively by following a qualitative approach, due to its unique ability to study evolving, dynamic situations. Comparisons and analyses between multiple (and perhaps even related) case studies is also promoted in this research approach (Johnson & Onwuegbuzie, 2004).

On the other hand, findings generated from qualitative studies may only be applicable to the exact context and sample population to which it was studied and are thus often not generalisable. Collecting and analysing data in these studies is also relatively time-consuming. Furthermore, testing proposed theories and hypotheses with this data is difficult to do in practise, making accurate, reliable qualitative predictions challenging to offer as contributions to the research field (Johnson & Onwuegbuzie, 2004).

2.3.3 Quantitative research approach

2.3.3.1 *Description and characteristics*

Researchers exercising this approach generate knowledge objectively by analysing statistical data that results from predefined equipment (Creswell, 2003). Research design gathers numerical data through surveys, experimentation as well as test and measurement processes, involving a statistical focus to analyse the acquired data (Leedy & Ormrod, 2005; Creswell, 2002; Creswell, 2003).

The strategy researchers follow in this approach belong to one of three main classifications: descriptive, exploratory and causal comparative. Firstly, a *descriptive*-type study observes a situation in its natural habitat, aiming to pinpoint which variables affect a particular phenomenon through either observation or studying the relationships between two or more variables. Secondly, an *exploratory*-type study aims to assess and measure the impact an intervention makes on a particular focus group, comprising of pre-experimental, true experimental and quasi-experimental types. Thirdly, *causal comparative* research studies the cause-and-effect relationship between variables to quantify how a dependent variable affects an independent variable in the situation or context being investigated (Leedy & Ormrod, 2005).

2.3.3.2 *Methodology, research design, data collection and data synthesis*

The quantitative research starts off by clearly defining a problem statement and forming a research hypothesis, followed by compiling a literature review, collecting numerical, empirical data and carrying out a quantitative data analysis (Leedy & Ormrod, 2005; Creswell, 2002). Methodology in a quantitative study holds true the assumptions of an empiricist paradigm, utilising mathematical models as the medium for data analysis and the resulting conclusions (Creswell, 2003; Creswell, 2002). Each of the three quantitative classifications made above have an accompanying methodology; only the *descriptive* study methods are discussed here, as exploratory and causal comparative types may also use these methods varyingly.

Descriptive-type quantitative studies employ four types of research methods: correlational, developmental design, observational and research surveys (Williams, 2007). The objective of **correlational methods** is to determine whether two or more variables affect one another, investigating the degree of correlation between these variables so that the Pearson Correlation Coefficient *r* is generated from statistical analysis (Bold, 2001; Leedy & Ormrod, 2005; Cooper & Schindler, 2001). Notably, the degree of validity and reliability of the collected numerical data is crucial in these methods as they directly influence the value of *r* (Leedy & Ormrond, 2005).

Developmental design studies the variability of properties in a study group over time, comprising of either cross-sectional or longitudinal types. **Observational** research employs optimal objectivity to study a specific component of human behaviour, next recording data in the chosen environment to yield conclusions and

facts related to the observed behaviour. Lastly, **research surveys** apply both closed-ended instruments and open-ended questions, collecting data from respondents who represent a given population to encapsulate the aspects of the desired phenomenon at that time (Leedy & Ormrod, 2005).

2.3.3.3 Benefits and drawbacks

Insights from Johnson and Onwuegbuzie (2004) were selected to synthesise the advantageous and limiting aspects of quantitative research. Hypotheses in this approach are established prior to obtaining data, implying a researcher can design their research methods and collect data with a clear purpose in mind. However, researchers may succumb to the confirmation bias by *testing* hypotheses and theories, meaning their focus may be diverted from the *development* of accurate theories and hypothesis based on studying the desired phenomena. In addition, the categories and theories utilised by the researcher in a quantitative study may not align with the needs and/or skillsets of local academic, political or social authorities (Johnson & Onwuegbuzie, 2004).

On the bright side, data collection and analysis in quantitative research can be complete faster than in qualitative approaches, yielding accurate, numerical data that is known to be more credible among academic authorities considering the research results. Although these findings are independent of the researcher, they can be generalised when applied to various population groups. Study findings in quantitative studies may, however, be too vague to directly and reliably apply to local circumstances and citizens that are more case-specific (Johnson & Onwuegbuzie, 2004).

2.3.4 Mixed methods research approach

2.3.4.1 *Description and characteristics*

A MM research approach gathers and synthesises both numerical and narrative data, implying both quantitative and qualitative approaches are applied in the same study (Creswell, 2003). The goal of mixing is to expand the perception of both the researcher and their associated academic field and assist in unifying the differences found in quantitative and qualitative research, enabling the researchers to both test and construct new theories and hypotheses (Onwuegbuzie & Leech, 2005; Carr, 1994). A variety of terms are used in this type of study to describe how the data from both approaches are interwoven and incorporate one another's distinct properties, such as integrating, synthesising and mixing (Creswell, 2009; Johnson & Onwuegbuzie, 2004).

MM studies utilise three methods of inquiry: 1) *inductive* reasoning (uncovering patterns and valid insights through observation), 2) *deductive* reasoning (testing theories and hypotheses) and 3) *abductive* reasoning, involving an iterative explanation process to best interpret the study's results (Johnson and Onwuegbuzie, 2004). Through a cyclical process of data collection and synthesis, a single study conclusion produced by the interaction of various academic perspectives is known to be more thoroughly considered and thus held more confidently by research communities evaluating the study (Johnson & Onwuegbuzie, 2004; Onwuegbuzie & Leech, 2005). As such, the MM strategy unlocks boundless potential for the future of academic research, capable of motivating shared responsibility in achieving enhanced quality of education (Johnson & Onwuegbuzie, 2004).

2.3.4.2 *Methodology and research design*

In order to construct a MM research design, the researcher must first decide whether or not the study will function within one dominant research paradigm, and whether the phases of the study are carried out *concurrently* (at the same time) or *sequentially* (in separate, distinct phases) (Johnson & Onwuegbuzie, 2004). Qualitative and quantitative approaches are generally mixed across three main stages: 1) defining the research objectives, 2) gathering numerical and narrative data and 3) synthesising and interpreting the mixed data. However, the most important aspect of a MM study is the research *question*, followed by the selection of research methods that carry the greatest potential in providing helpful answers to these questions. Multiple methods are used to broaden the capabilities of the study to answer the research questions, combined in such a way the benefits of the methods complement one another and the weaknesses are significantly reduced (Johnson & Onwuegbuzie, 2004; Johnson & Turner, 2003).

There are four vital aspects that affect the design and methodology of MM research and assist in shaping which processes are followed in the study, namely *timing, weighting, mixing and theorising* (Creswell, 2009; Mertens, 2003).

2.3.4.2.1 Timing

Timing involves deciding whether the quantitative and qualitative data will be gathered in phases (sequentially) or simultaneously (concurrently). If sequential timing is chosen, the researcher can decide whether to collect quantitative or qualitative data first, based on the initial intention of the study. Otherwise, if concurrent timing is selected, both types of data are collected simultaneously whilst in field and thus synthesised simultaneously (Creswell, 2009). While it may be a great deal of effort to collect and analyse both quantitative and qualitative data simultaneously, Creswell (2009) advises that its more practical and efficient to gather both types of data at the same time while in the field, instead of needing to return a second or third time.

2.3.4.2.2 Weighting

Weighting determines whether the researcher prioritises using either quantitative or qualitative data in the study, thus evaluating the extent to which one data type is used over the other. The selection of weighing is based on the research purpose, the intention of the researcher and the audience considering the research (Creswell, 2009).

2.3.4.2.3 Mixing

Next, *mixing* assesses how, when and to what extent the philosophies, perspectives and data used in either research approach is combined. The integration of this information can take place at any of the data collection, data analysis or discussion sections, involving three main forms of mixing:

1. quantitative and qualitative information can be integrated between *two specific phases*
2. integrating data only when *quantitative and qualitative data are merged*
3. *embedding* – collecting one type of data to reinforce the findings of the other data type

2.3.4.2.4 Theorising

The researcher should then decide whether a specific theory, perspective or philosophy is used to guide the research design in the *theorising* aspect. Notably, these approaches should be selected with careful consideration and justification, as it strongly influences how the researcher perceives the research problem, local research context, research questions and selection of study participants, as well as the insights and implications generated from the findings (Creswell, 2009).

2.3.4.2.5 Mixed-methods design strategies

Creswell (2009) offered six design strategies in which to carry out MM research, namely a sequential *explanatory* strategy, sequential *exploratory* strategy, sequential *transformative* strategy, concurrent *triangulation* strategy, concurrent *embedded* strategy and concurrent *transformative* strategy. These

strategies are generally divided into sequential (phase by phase) or concurrent (simultaneous execution). Decisions as to which strategies are chosen were made and justified in section 3.6.

Creswell (2009) provides a few guidelines to select the most apt strategy. Firstly, present the data and characteristics of the study in type of diagram to visualise all aspects in the research process. The researcher should then consider how much time is available to collect data, as concurrent strategies collect both quantitative and qualitative data simultaneously in the field and is thus less time consuming. It is suggested that an embedded model strategy is applied when time is limited. Furthermore, for students who are more experienced with quantitative research and are not that well acquainted with qualitative research, the author suggests a sequential explanatory approach is followed (Creswell, 2009).

2.3.4.3 *Sampling, data collection and data synthesis*

Teddlie and Yu (2007) offer five strategies for MM sampling. Firstly, *basic* sampling involves the combination of quantitative and qualitative sampling. Secondly, the first sampling phase informs the second sampling phases in *sequential* sampling, while *concurrent* sampling blends quantitative and qualitative processes either independently or in the most complementary way. Fourthly, sampling takes place in two or more planes of analysis in *multilevel* sampling and lastly, a *combination* of any of the four strategies presented can devised (Teddlie & Yu, 2007). Sampling processes for MM research proposals should be carefully considered, extensively planned and presented well, given both quantitative and qualitative data is collected, mixed and presented complementarily (Mertens, 2003).

Following the selection of a sampling strategy, Mertens (2003) advises that researchers identify and be clear about which forms of data they wish to gather in their study. Research methods for collecting data can either be open-ended or closed-ended – for instance, numerical (quantitative) data can be collected by distributing surveys with closed-ended questions, followed by facilitating a set of interviews with open-ended questions to collect narrative (qualitative) data (Mertens, 2003; Williams, 2007).

Researchers can follow a process of *legitimation* to evaluate the reliability of both data types and the way it is interpreted by other scholars. Although this process may include extra data collection, data analysis and discussion, it serves in validating the applicability and accuracy of the data and the consequent findings. Therefore, the researcher should clearly explain the series of steps taken to validify the accuracy and reliability of the quantitative and qualitative findings as a means of legitimation. This would also mitigate any alternate explanations from the researcher's academic community or the publishing of updated research to amend mistakes in the findings (Onwuegbuzie & Teddlie, 2003).

2.3.4.4 *Guidelines for mixed methods research*

Besides the other recommendations made by scholars, Mertens (2003) provides tips and advice to improve the quality and efficiency of MM research. *Data outliers* that diverged from the sample's standard deviation should be investigated to propose helpful insights explaining the phenomenon. Follow-up interviews, data collection or analysis can be undertaken to do so. In addition, as a way for MM researchers to clearly communicate the procedures they follow in their study, *MM notations* can be studied. These set of simplified symbols, labels and language help describe the approach followed in a MM study in a diagrammatic form in order to communicate vital aspects such as actions, milestones and different types of data collection (Mertens, 2003).

A research report structure is also suggested for a sequential MM study. It is recommended that quantitative data collection and data analysis is completed first, followed by conducting qualitative data collection and data analysis to reinforce any findings uncovered in the quantitative section. Then, the researcher is prompted to present a discussion section as well as a conclusion section to interpret the research findings, also explaining how the qualitative results complemented and reinforced the quantitative results (Mertens, 2003).

2.3.4.5 *Benefits and drawbacks*

Data collection and the analysis of both numerical and narrative data in a MM study is far more time-consuming and expensive than quantitative- or qualitative research. A team of researchers may thus be needed to implement both approaches and collect their respective data. In extension, a MM research must also be familiar with both quantitative and qualitative research approaches, as well as how various research methods and data can be combined in an efficient way. Thus, far more effort and time is needed to produce a MM study of a satisfactory quality and reliability (Creswell, 2009; Johnson & Onwuegbuzie, 2004).

However, by using both quantitative and qualitative approaches, the strengths of one approach can neutralise the weakness of the other and provide a more complete, well-rounded set of information that explains the phenomena and behaviour being studied. As a result, numerical data can be used to support the insights from narrative data in the form of behaviour, pictures or words, thus producing more accurate and widely-generalisable results. Due to the collaboration between different methods of research and the integration of their data and techniques, conclusions and findings generated by the study are trusted to a greater degree by the associated research community. Merging both approaches also allows for more detailed research questions to be posed and answered, even if these questions may still be a mystery or an impossibility in the research field (Johnson & Onwuegbuzie, 2004).

2.4 Investigating the study constructs

2.4.1 Background

This study uses a MM strategy to investigate the impact of blending the key aspects of HCD thinking (having a *qualitative* weighting) and PT design (having a *quantitative* weighting) on the quality, desirability and operational success of South African PT services. To do so, it is imperative that each construct is studied and defined *separately* before they are blended, to first understand their unique properties, strengths and weaknesses. Thereafter, the researcher aims to combine the similarities, account for the discrepancies between these two manners of thinking as well as balance their strengths and weaknesses to produce a list of human-centric PT design (HCPTD) principles.

2.4.2 Defining the constructs

2.4.2.1 *Human-centric design*

HCD thinking can be described as an innovative process of problem solving that begins with understanding the perspective and central needs of those who are faced with a problem and ultimately designing services, products or systems tailor-fitted to meet those needs (Design Kit, 2021; DC Design, 2017). The general HCD process begins by empathising with the needs of the target sample group being designed for and brainstorming a plethora of different ideas that could meet their needs. Next, several prototypes of valid solutions are constructed and presented to the sample to assess whether they sufficiently meet their needs or not, after which the best prototype is optimised based on the sample's feedback and given to the world as a final product (DC Design, 2017).

Since these ideas are inspired by real people using the product or service, those who face a problem become an integral part of the design team, assessing whether or not the solution offered satisfies their stated needs (Thomsen, 2018; DC Design, 2017). Human-centric designers aim to utilise every aspect of a proposed product or service in order to offer as much benefit and pleasure to those they are designing for, aiming to create products that align with the personal preferences of the user and thus cultivate a mood of support, collaboration and personal connection (Thomsen, 2018). Thus, the design process is driven by the needs and aims of the person using the proposed product or service, instead of the organisation's goals, integrating these needs into the functionality and interface of the product or service (Norman & Draper, 1986; Rogers, Sharp & Preece, 2015).

As a means of receiving the best results from the HCD process, designers should, when communicating with people, rephrase the problem at hand in human-centred terms and request that people clearly express their thought process while using the product to highlight which aspects of the product they enjoy and where it falls short in meeting their needs. Furthermore, it is recommended that designers make use of in-

person conversations to gather rich, new insights and go explore the contexts in which the product is used by the sample in the real world to understand how the product can be better designed to align with people's needs and expectations (Thomsen, 2018).

2.4.2.2 *Public transport*

The term "public transport" (PT) can be defined as any local means of passenger or freight transportation available to transport users and where service providers are paid for offering this travel service (Kitchin & Thrift, 2009). These services allow a greater number of passengers to be transported at once along specified travel routes, either operating on chosen time intervals or on the basis of when the vehicle is at full capacity (Conserve Energy Future, 2021). While public transportation comprises of a multitude of different modes including buses, cable cars, trains, taxis and streetcars such as tuk-tuks (Conserve Energy Future, 2021), this study focuses only on three modes in particular: minibus taxis (MBTs), bus rapid transport (BRT) and rail transport (trains), given that these are the three main PT modes in South Africa (STATS SA, 2018).

In small- and medium-sized cities, high-quality public transportation (HQPT) describes the ability of a transport system to be competitive with the use of private automobiles, thus requiring the following characteristics: reliability, safety, comfort, speedy transfers, affordability and the ability to be clearly understood and utilised. Additionally, HQPT can also be defined as a PT system with optimised productivity and a high commuter desirability for the service. While a ratio of high passengers to a reduced expenditure is preferred, PT designers should always prioritise a high number of passengers (Directorate General for Energy and Transport, 2010).

2.4.3 Key principles

Existing design principles used in HCD and PT design, respectively, are synthesised in this section to consider which principles are used by these two research fields. The intention of doing so is to gather ideas of foundational principles in either field to create platform for the creation of the final HCPTD principles, by blending the most applicable principles from both fields. While ideas from literature were used to produce some initial principles, the researcher also intends to create brand new principles for either study construct based on new insights and information attained during data collection.

2.4.3.1 *Human-centric design principles*

Principle 1: "Understand and address the core problems" (jnd.org, 2019; Babich, 2018)

- Keep asking 'why?' until you arrive at the core problem
- There may be several "core issues" causing a problem
- Address the "core, root issues" instead of just the symptoms of these issues
- By solving the core problem, you may "solve a root cause of other problems"
- Be sure to invest your resources into solving the *right* problem

Principle 2: "Be people-centred" (jnd.org, 2019; Babich, 2018)

- Begin with the "needs and abilities of people"
- Consider "all the people who are involved"
- Account for the "history, culture, beliefs, and environment of the community."
- Search for answers by interviewing people who live in the community applicable
- Remember that "your product is just a tool that helps them reach their goals more efficiently"
- "Identify the real reason why people want to use your product"

Principle 3: "Think of everything as a system" (Babich, 2018; jnd.org, 2019)

- Ensure designs "focus upon the entire activity under consideration, not just isolated components"
- Always remind yourself of "what you want your users to achieve with your product" – this is the result you should be most invested in
- Note that there may be "tensions, conflicts, and differing perspectives among the multiple participants" in the project

Principle 4: "Use rapid iterations of prototyping and testing" (jnd.org, 2019; Babich, 2018; Mad Pow, 2021)

- "Create a large pool of possible solutions" that the team can study and choose from
- "Always test your solution with real people"
- Feedback makes it clear where your design needs to be improved

- Careful consideration as well as several iterations and revisions may be necessary to apply alterations to a prototype so that it is ready to use
- "The prototype becomes more refined and usable" with every revision
- Do not assume that other people believe the same things as you and will thus behave in a similar way – "you are not the user!"

Principle 5: "Great design comes from cognitive empathy and emotional empathy" (Mad Pow, 2021)

- I.e. "understanding people's behaviours, thoughts and emotions"
- Learn about how people perceive and interpret the problem of interest

Principle 6: "Great design comes from a desire to create real outcomes" (Mad Pow, 2021)

- "Design is about achieving objectives"
- Consideration is applied on how progress and success is measured

2.4.3.2 *Public transport design principles*

Principle 1: "Simple and direct network structures (Nielsen et al., 2005)

- Arrange networks "on the principle of 'one section – one line'"
- "Provide simple direct lines whose physical routes can be easily remembered"

Principle 2: "Plan for speed, consistency and reliability" (Nielsen et al., 2005; Mees, 2010)

- Aim for travel speeds to be "comparable or faster than door-to-door travel times that can be achieved by car"
- PT vehicles must be able to travel swiftly along routes "with minimal impedance from other traffic or intersections to ensure reliability"
- Priority for these vehicles needs interventions such as "right-of-ways, dedicated lanes and priority at intersections"
- "Lines should operate consistent timetables"

Principle 3: "Coordinate convenient transfers" (Thompson et al 1976; Nielsen et al 2005; Dodson et al., 2011)

- "Journey speeds also depend on quick transfers"
- Main task within network is to "provide a basic structure of lines operating at high frequency so that waiting times at stops on these lines are minimal"
- "Fast and easy transfers support fast journeys to dispersed destinations within a public transport network"

- Since pedestrian routes are an "extension of the PT network", they must be designed with the same principles as the PT network: "speed, connectivity and legibility"
- "Stop and interchange design is an important factor to ensure passenger safety, comfort and ease of use."

Principle 4: "Provide clear, ubiquitous and consistent information and marking" (Dodson et al., 2011)

- Enough information should be provided at stops for commuters to find other mode stops and find their way around the PT network
- Provide information on: "timetable frequencies for services..., zones and fares."
- Naude, Jones and Louw (2005) presented planning-, transportation and urban design guidelines when providing design guidelines for PT facilities. Given that the study is mainly focused on public transportation and not necessarily its planning, mainly transportation- and urban design principles most applicable to the study's scope were chosen and paraphrased. The chosen principles are believed to be most applicable to the study's objectives and most capable of satisfying customers and enhancing PT service quality as a result, while service the operational success of these services.

Principle 5: Specifying the "function and role" of each mode (Naude, Jones & Louw, 2005)

Principle 6: Enhancing the "total travel experience" (Naude, Jones & Louw, 2005)

Principle 7: Providing "access to the greatest possible number of people" (Naude, Jones & Louw, 2005)

- "Provide a minimum transport service to all citizens irrespective of car availability, physical abilities and area of residence" (Nielsen & Lange, 2008)
- "Areas with little public transport demand must have other transport solutions to give access to the stops, stations and interchanges of the main public transport network" (Nielsen & Lange, 2008)
- PT services should be designed and offered as attractive, inclusive services that consider all types of users and is universally accessible (Nielsen & Lange, 2008)

Principle 8: "Integration" (Naude, Jones & Louw, 2005)

Principle 9: "Universal access" (Naude, Jones & Louw, 2005)

Principle 10: "Organisation and transport policy" (Nielsen & Lange, 2008)

- "Institutional factors may strongly affect the opportunities for overall planning of network (Nielsen, Nelson & Mulley, 2005)
- A form of "regional structure" is argued by scholars for be imperative (Colin Buchanan & Partners, 2003; ECMT, 2002).

- "A willingness to commit funds to both operations and infrastructure by relevant stakeholders" would be capable of attracting more financial investment from commuters (Colin Buchanan & Partners, 2003; ECMT, 2002).
- National policies should be support and complement transportation policies (Colin Buchanan & Partners, 2003; ECMT, 2002).

Principle 11: "Long-term stability" (Nielsen & Lange, 2008)

- Needed for the system to "influence urban development and create more sustainable transport patterns"
- System must also be able to "adapt dynamically" to new commuter needs and the economic paradigm of the PT system
- This can only be achieved if the system can effectively process "short-term adjustments in frequency, capacity, … and branches"
- "Even conversions of transport corridors between bus and rail should ideally be possible without completely altering the network structure of the urban region."

Principle 12: "Robust and simple structure for major market segments" (Nielsen & Lange, 2008)

- Easier to achieve when system comprises of "as few, clearly defined lines as possible"
- Commuters then perceive and recall PT services more easily
- PT service is then simpler to "market, brand and sell"
- PT services is then "simpler to plan and operate"

2.4.4 Investigating elements of existing models

2.4.4.1 *Introduction*

This study intends to blend the key aspects of HCD and PT design in order to propose solutions relevant to the Gauteng civil engineering industry. Figure 1 illustrates this intention with a basic Venn diagram. As a means to familiarise the researcher with the research field of either study aspect, while ensuring the process of conducting research and presenting literature is well-informed, a series of HCD- and PT models were analysed to understand the specific context of either study aspect. This section reviews the key design elements of both HCD- and PT systems reflected in international research to ensure all factors and requirements essential for an efficient, robust yet human-centric PT system are considered.
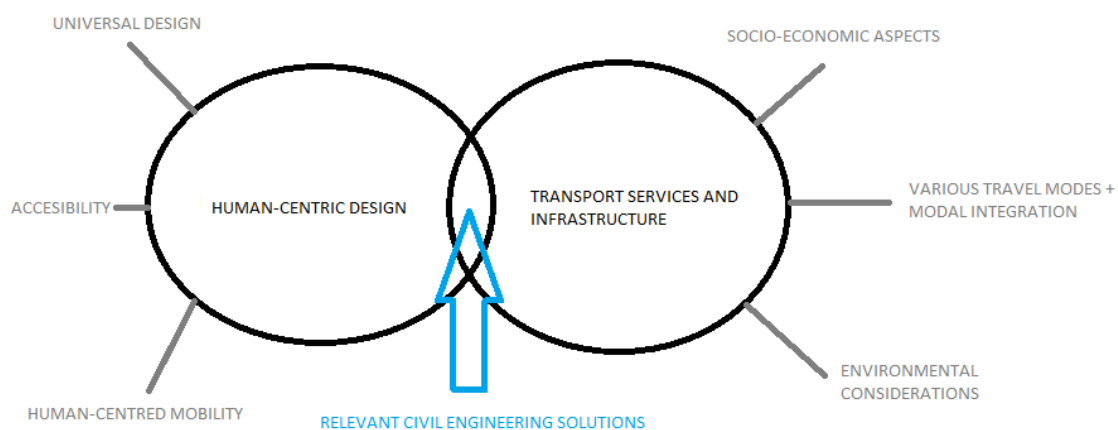
Figure 1: Combining human-centric design and transport services and infrastructure to produce relevant civil engineering solutions

2.4.4.2 *Human-centric design models*

Insights were provided by Deloitte specifying that a mindset shift on design thinking is necessary to offer an improved service experience to a customer. The model is shown in Figure 2. Traditionally, problem solving has been based on identifying organisational goals, constructing design concepts and then adapting these concepts to meet the needs of stakeholders. However, more recently, a need has emerged to firstly understand the stakeholders of a service, then create concepts and build functional systems (Fishman et. al., 2019).
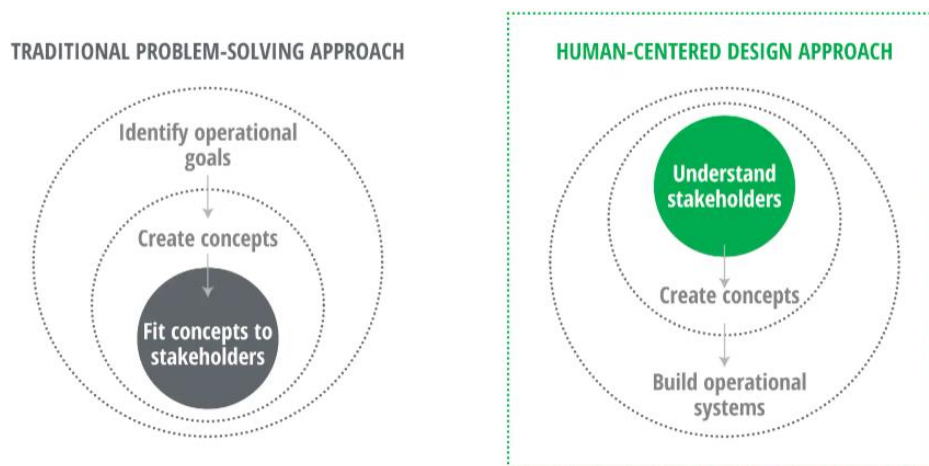
Figure 2: The human-centred design approach (Source: Fishman et. al., 2019)

A similar design approach is suggested by Invitro Innovation (2014) (as shown in Figure 3), in which the problem is first understood by investigating existing research, then empathising with and defining the user's needs. Following this, a set of ideas are developed that could satisfy these user needs, a prototype of the relevant ideas is constructed, and feedback is obtained from the user to optimise the prototype design. Dalberg (2020) presented a three-phased model to human-centric design, presented in Figure 4. Phase 1 involves *planning* to understand the feasibility of the study and opportunities that can be unlocked with research. Phase 2 involves following an iterative loop from first *learning* about the user's existing needs and behaviours, collaboratively *creating* a design to meet these needs, *testing* the solutions at various levels and *measuring* the effectiveness of the solution with data to refine its design. After following enough iterations and testing solutions, successful prototype designs are *scaled* in Phase 3.
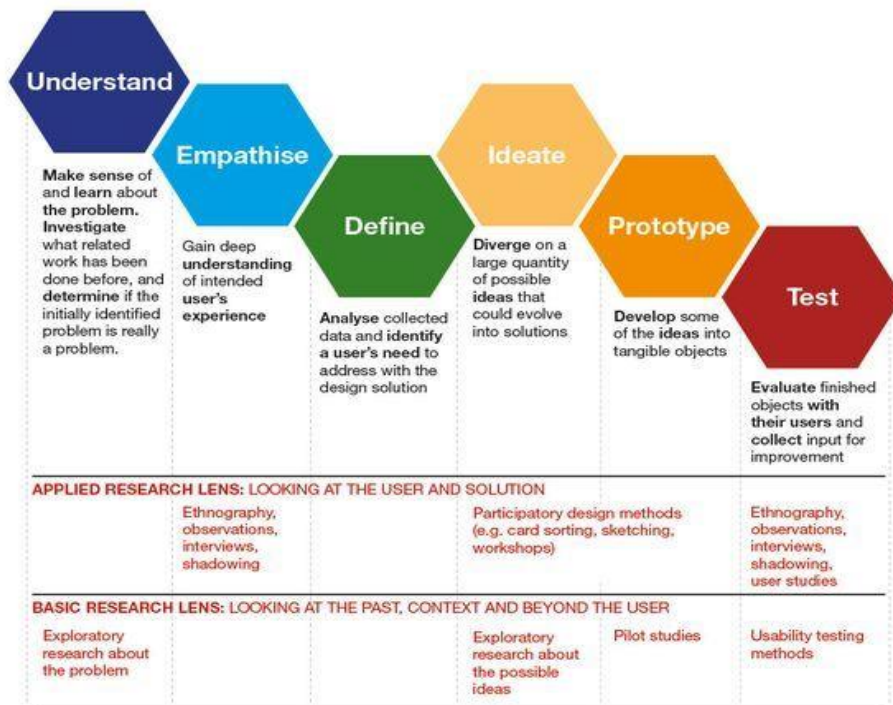
Figure 3: The human-centred design thinking process (Source: Invitro Innovation, 2014)
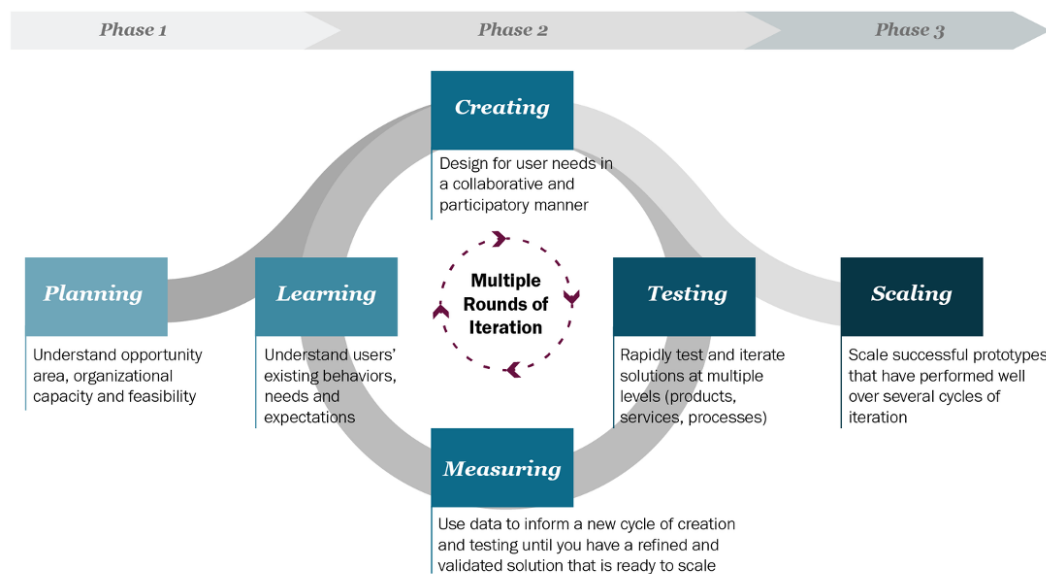
Figure 4: A phased human-centric design process (Source: Dalberg, 2020)

Clearly, the HCD models considered above seem to follow a similar design approach. The model in Figure 3 involves understanding, empathising with and defining the needs of users and associated stakeholders, as well as generating ideas and perspectives that could evolve into solutions. These steps can be likened to the planning, learning and creating elements of the model in Figure 4. In the context of PT services and infrastructure design, the four steps in Figure 3 could be likened to the literature review of this study, whereas the remaining model elements of prototyping and testing are only considered in the design, data collection and results sections of this study.

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2.4.4.3 *Public transport models*

The model in Figure 5 illustrates the dependent relationship between human behaviour, transport infrastructure and public space. The triangle between these components indicates that the utilisation of public space and development of transport infrastructure link with human needs via each commuter's travel behaviour and perception of PT. Transport infrastructure and public space designs function in the physical-social environment and should interact with one another to achieve effective integration, and with people to motivate behaviour changes that result in healthier lifestyle. Moreover, human behaviour functions in the physical-social- as well as the policy environment, where initiatives such as combined policies and public participation are developed. The degree of integration of a project is evaluated based on its associated 'solution space', i.e. the considered scope of both the policy and physical-social environments (Yang et al., 2019b).
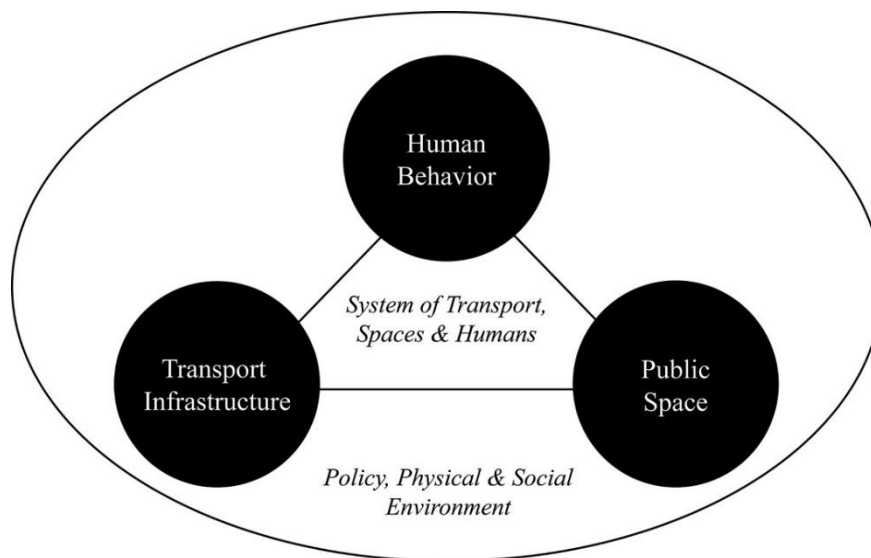
Figure 5: Integrated design of transport infrastructure in public spaces considering human behaviour

(Source: Yang et al., 2019b)

CIPTEC (2018) offers a 'Toolbox for Public Transport Innovation' model to equip transport stakeholders with approaches to innovation necessary to make PT services more desirable to the public. The model is shown in Addendum A. The first phase in this innovation flow is *understanding the existing situation* by observing social and market trends, as well as investigating the demands of commuters and what PT authorities and operators require from the supply perspective. These insights should be synthesised into a list of *objectives* for development. In the second phase, *existing approaches and solutions* with innovative aspects relating to PT and other sectors should be considered, followed by setting up and executing an *innovation strategy plan* in the third phase. This plan addresses the development's feasibility, business models and plan of action. Plans can be collectively generated by co-creating new designs with the public, involving transport sector experts and adapt existing innovative designs.

2.5 Sampling

A general overview of the variables involved in sampling design were discussed in this section. Sample design consists of two main types of sampling methods: probability sampling and non-probability sampling (Ali, 2014; Hair et al., 2007). However, as discussed in the research design (section 3.7), no probability sampling techniques were used in this study. Thus, only non-probability sampling techniques were discussed. The information synthesised in this section serves to educate the researcher on how to best design the research so that high quality and reliability is maintained, and literature support for the study's research design is provided.

2.5.1 An introduction to sampling

2.5.1.1 *Population, N*

On the greatest research scale, the term *population* (N) describes all the people, case studies or objects related to the topic the researcher is investigating in their study (Hair et al., 2007).

2.5.1.2 *Sample, n, and sampling*

In order to limit the amount of effort and financial investment that would have been necessary to study the entire population, a small portion of the population known as a *sample* (n) is chosen from a sampling frame, a list that includes all the members of the population that can form part of the study's sample (Creswell & Clark, 2017). Through a process called *sampling*, the behaviours, attributes and mindsets of this group of units can be quantified and used to imply particular findings about the greater population (Hair et al., 2007; Hanlon & Larget, 2011).

Each member of a sample is a representative of the population and are selected based on the population size, the sampling strategy selected and those who are willing to participate in the study (Hanlon & Larget, 2011). Therefore, sampling techniques are applied so that studies are more cost-effective, the necessary data is collected faster, and their findings are more accurate and dependable, also allowing researchers to overcome any geological accessibility limitations when selecting respondents (Cooper & Schindler, 2001; Hanlon & Larget, 2011).

According to Etikan, Musa and Alkassim (2016), the selection of a specific sampling strategy should align well with the assumptions, purpose and objectives of the study it is being employed in (Etikan, Musa & Alkassim, 2016; Morse & Niehaus, 2009). However, regardless of the strategy employed, the researcher should ensure the legitimacy of the strategy and the ease at which the sample is chosen is made priority (Morse & Niehaus, 2009). To simplify the manner in which data is collected, a researcher should ensure that the sampling budget, work plan outlining the procedure in which data is collected and research

instruments are designed *prior* to visiting the data collection; a pilot study can also be completed beforehand to allow the effectiveness of the research instruments to be optimised (Ali, 2014).

2.5.1.3 *Sampling techniques in mixed-method studies*

In the case of a MM study, researchers are required to carefully consider what type of data they wish to collect as well as the selection of the members of their sample (Mertens, 2003). Furthermore, the selection of a particular sampling technique should be justified well, while the approach should be thorough, planned in detail and showcased systematically to ensure both the qualitative and quantitative aspects of the research are utilised, blended and presented in a complementary way (Creswell, 2009; Mertens, 2003).

Teddlie and Yu (2007) offer five MM sampling techniques, namely basic, sequential, concurrent, multilevel and combination. *Basic* sampling involves the simple combination of qualitative and quantitative sampling, *sequential* sampling involves the first sampling phase informing the second and *concurrent* sampling marries qualitative and quantitative techniques in the most complementary way. Sampling takes place in two or more planes of analysis in a *multilevel* sampling approach, while a *combination* of any of the latter approaches can also be applied (Teddlie & Yu, 2007).

2.5.2 Non-probability sampling

In cases where limited information is available on the population of interest, researchers can apply a non-probability sampling technique that make use of a more personal approach to selecting the participants in their sample (Battaglia, 2008). As a result of this subjective selection approach, the likelihood of each member of the population being included in the sample is not the same (Battaglia, 2008; Hair et al., 2007).

Non-probability sampling can generally be implemented more swiftly and at a lower cost than its random sampling counterpart, but this depends greatly on the variables involved in the study, such as the population under investigation and the amount of data that is required (Battaglia, 2008; Elliott, 2020). The subjective sample selection process followed implies that non-probability sampling is generally used in more qualitative studies (Elliott, 2020), the findings thereof offering greater internal validity than external validity (Bernard, 2002).

While seven main non-probability sampling methods exist (namely quota-, convenience-, purposive/judgmental-, snowball-, heterogeneity-, modal instant- and expert sampling), only the sampling techniques utilised in this study were discussed.

2.5.2.1 *Convenience sampling*

As the name suggests, the convenience sampling method gathers data from respondents with desired attributes that are within a comfortable distance from the researcher, practical for the researcher to access as well as available and prepared to participate in the study. Therefore, the sample selected more convenient for the researcher to access and collect information relating the topic of interest (Etikan, Musa & Alkassim, 2016; Hair et al., 2007; Dörnyei, 2007). A good example of convenience sample participants are students in the same university as the researcher, as they are generally available and would be willing to participate (Dörnyei, 2007; Explorable.com, 2009).

Convenience sampling techniques can be used in both qualitative and quantitative studies but are more often used in quantitative research as its main focus is making sure the sample findings can be reliably generalised to the overall population (Explorable.com, 2009; Miles & Huberman, 1994). Gathering data from respondents using this approach is simpler and more cost-effective than other sampling strategies, while the legitimacy of a convenience sample results rises with a larger sample size (Explorable.com, 2009; Hair et al., 2007; Suen, Hwang & Lee, 2014). It is, however, necessary that a researcher explains how the contrast between a convenience sample and one that is selected randomly affects the study, also discussing whether participants with desired characteristics are fairly represented in the sample by using a convenience approach (Explorable.com, 2009).

While a convenience sampling approach may offer various benefits to a researcher, the dependability of the results is affected by several limitations. Firstly, due to the subjective nature of the sample selection, convenience samples may suffer from unseen selection bias that affects the generalisability of the results, meaning there is no certainty that the sample would accurately represent the population of interest (Hair et al., 2007; Mackey & Gass, 2005). Thus, there exists the risk of obtaining data from candidates that do not reliably represent the characteristics of this population and the study's research problem, in turn resulting in criticism from the associated academic community that makes it challenging for the research findings to be embraced (Hair et al., 2007; Oppong, 2013).

Secondly, outliers present in the sample data may have a detrimental impact on the quality of the data and the accuracy of the findings. Outliers are defined as participants in a sample that are considered out of place and do not align with trends found in the sample. When respondents are chosen conveniently and do not align with the research problem or qualities required in the sample, this may distort the relationship between the variables of interest and the trends that result, thus negatively impacting a precision and dependability of the study's findings (Hatch & Lazaraton, 1991).

2.5.2.2 Purposive sampling

Also known as judgement sampling, a researcher begins by defining a sampling objective and what type of information is required to answer the study's research questions: the most vital consideration in a purposive study, influencing the research objectives and in turn the design of the research methodology (Etikan, Musa & Alkassim, 2016; Bernard, 2002; Laerd Dissertation, 2012; Tongco, 2007). It is imperative to clearly specify what qualifies a respondent to be part of the sample, ensuring each respondent chosen aligns closely with what is considered the norm of the population being studied (Allen, 1971). After specifying which attributes of the population being studied are required in the sample to answer the research questions, researchers then proceed to use their own judgement to identify candidates for the sample who could offer the information necessary to realise this objective (Louangrath, 2015; Etikan, Musa & Alkassim, 2016; Creswell & Clark, 2017; Etikan & Bala, 2017). Therefore, the questions asked must be designed and phrased in such a way that the researcher obtains the necessary information from the respondents selected (Zelditch, 1962).

The respondents chosen should be sufficiently informed about the topic of interest, have experience or opinions to share on the phenomenon being studied and are both available and interested to share their personal views. Candidates with the desired knowledge and characteristics who can share their personal insights in a detailed way are then chosen and, if they are willing, data is gathered to inform the research question (Etikan, Musa & Alkassim, 2016; Creswell & Clark, 2017; Etikan & Bala, 2017; Bernard, 2002; Creswell, 2009; Hair et al., 2007; Spradley, 1979). Collecting data in certain areas may not be allowed or more challenging to accomplish, while some people may be not have the time or willingness to participate, meaning availability and accessibility are two key considerations in purposive research (Bourdeau, 1953).

Purposive sampling techniques are generally utilised in qualitative research, not needing a fundamental theory or principle to inform its sample selection (Explorable.com, 2009; Bernard, 2002). Known to be an affordable and practical method of compiling a sample and yielding dependable data, this sampling technique prioritises data saturation, where the sampling process endures until the researcher has a satisfactory overall perspective of the phenomenon being studied and no more helpful information can be found (Hair et al., 2007; Miles & Huberman, 1994). Therefore, the size of a purposive sample depends on where data saturation is reached (Suen, Hwang & Lee, 2014), implying there is no particular limit to its sample size (Bernard, 2002).

2.5.2.3 Snowball sampling

In cases where the researcher has a limited understanding of the population being studied, the snowball sampling approach can be applied to simplify and enhance any communication needed to select the sample (Etikan & Bala, 2017). At first, the researcher invites a few people with attributes that align with the desired

sample qualities and the topic of interest. Each member of the sample is then asked to utilise their network of contacts to invite other people with similar attributes to participate in the study, thus expanding the sample size similar to how a snowball grows in size as it moves (Etikan & Bala, 2017; Hair et al., 2007). One major risk of using this sampling approach is that the quality and dependability of the sample relies fully on the participants chosen initially (Etikan & Bala, 2017), meaning the researcher should have a clear idea of which attributes the sample requires and select the correct people to ensure the research problem is accurately represented.

2.5.2.4 *Expert sampling*

As the name suggests, this sampling strategy includes professionals in the sample who are well experienced in the context of the study and can offer valuable, expert opinions to better inform the topic of interest. As a test of the feasibility of the study, expert sampling is usually employed in the exploratory part of a qualitative study when researchers are studying unexplored research topics and want to gain insight from experienced experts before continuing without proper understanding of the topic. These reliable views can illuminate unseen areas of research and be utilised to provide helpful guidance to inform the study's progression, perhaps even forming the foundation of a study's approach. Expert sampling can be used to test the accuracy of a different sampling technique and is helpful in studies where there is insufficient literature on the topic being studied or obtaining findings may take longer than usual (Etikan & Bala, 2017; Etikan, Musa & Alkassim, 2016; Laerd Dissertation, 2012).

2.5.3 Sample size

2.5.3.1 *Introduction*

Calculating the correct sample size is vitally important to ensure the researcher collects enough reliable data, influencing to a large extent the selection of statistical methods used to process the data and the accuracy of the findings that they produce (SurveyMonkey, 2021a; Rahi, 2017). As such, the goal of determining the sample size is to produce results within a specified accuracy range and level of confidence at the lowest possible expenditure, while mitigating any errors or biases that could likely result from the sample selection (Ali, 2014; Taherdoost, 2016). The research hypothesis and research questions are the most important considerations when determining the sample size, rather than the probability- or non-probability sampling techniques being used (Ahmed, 2016).

There is no limit to the size of a sample. However, it is very costly and challenging to persuade a huge number of respondents to participate in the study, especially when collecting data in public (SurveyMonkey, 2021a). Therefore, the size of a study's sample is a function of the size, variability and availability of the target population, the funds available in the study and which sampling strategy is being

applied. Furthermore, it is also affect by the statistical methods being used, the research objectives and the degree of accuracy the study aims to achieve (SurveyMonkey, 2021a; Ali, 2014; Taherdoost, 2016).

It is important to note that any other researcher should be able to replicate the chosen sample and research findings of the original study by using the same sampling design methodology. This allows the study's results to add value to its field and be accepted by its associated academic community. To ensure the sample and results are reproducible, develop a structured procedure for selecting respondents to collect a specific type of information and explain this procedure in detail, also defining the sampling frame that describes what qualifies a person to be part of the sample (Hones, 1990).

2.5.3.2 Reliability, validity and competency of respondents

When selecting a sample for a study, it is critically important to ensure the people chosen have both the necessary understanding and expertise to be part of the sample. Otherwise, the information provided by the participants can be considered unreliable, resulting in research findings that lack integrity and accuracy (Godambe, 1982). For this reason, the study requires that each respondent chosen has the necessary reliability, validity and competency to form part of the sample so that the study yields dependable results.

2.5.3.2.1 Reliability

Relating to the insights provided by Hones (1990) above, the term *reliability* describes the degree to which a study's results can be replicated by any other researcher in another study by applying the same methodology as the original study, also providing an indication of the dependability of a sample participant's responses and the degree to which similar responses are noted in the sample population (Hones, 1990; Louangrath, 2015; Bernard, 2002; Alexiades, 1996; Bernard et al., 1986). Respondents may provide unreliable information due to having ulterior motives, wanting to impress the researcher or satisfy their desires, or because the integrity of their responses are tainted by their own perspectives or personal issues (Alexiades, 1996; Bernard et al., 1986).

Researchers can enhance the reliability of their data by optimising both the interview setting and the way in which the participant is interviewed to ensure the participant feels safe, relaxed and comfortable enough to engage with the topic and share their truths (Alexiades, 1996; Bernard et al., 1986), while also attempting to phrase the questions less personally and more objectively, as more private, subjective questions tend to offer more subjective and thus less reliable responses (Seidler, 1974; Poggie, 1972). Notably, a study would fail in terms of reliability if the original findings cannot be replicated in another study, meaning the findings from the original study cannot be considered dependable and accurate (Louangrath, 2015).

2.5.3.2.2 Validity and competency

The term *validity* describes the degree to which the expected results vary from the observed information (Louangrath, 2015), meaning a study's findings are valid if the results are either the same or vary to a small degree from the observed information. Lastly, the term *competency* indicates whether a person has the skills, capability or qualifications to provide the researcher with reliable responses relating to the topic being investigated (Bernard, 2002).

2.5.3.3 *Confidence levels and margin of error*

As the name suggests, a *level of confidence* (LOC) indicates how confident one can be that a study's findings are correct, while the *margin of error* (MOE) specifies in which range the study's results would fall with the same LOC (SurveyMonkey, 2021a). The number of units in survey sample greatly affects the LOC as well as the allowed MOE of the data, implying the errors made in the sampling process reduces and the legitimacy of the results rise as the sample size tends toward the population size (SurveyMonkey, 2021a; Philip, 2012). However, as mentioned above, sampling the entire population would be both cumbersome and costly (SurveyMonkey, 2021a), meaning a researcher should select a cost-effective sample size that would offer an acceptable LOC and MOE, while producing accurate, good quality results (Ali, 2014; Taherdoost, 2016).

As the sample size diminishes, a reduced LOC and thus an elevated MOE would result, suggesting that the dependability of data falls. As the sample size increases, the MOE falls and a greater LOC can be expected, implying the data can be expected to be more reliable. Ultimately, the priority of data collection is to gather honest information from enough respondents to ensure the data is reliable enough to make accurate generalisations; a realistic sample size should be selected to guarantee this priority. To ensure precise, reliable results that can be achieved realistically, a standard LOC of 95% has been set with a corresponding 5% or 2.5% MOE: anything more may be too expensive or difficult to achieve (SurveyMonkey, 2021a).

2.5.3.4 *Sampling and non-sampling errors*

Two main types of errors arise in a study's data: sampling errors and non-sampling errors. *Sampling* errors are inevitable and arise from using a sample instead of the entire sample population to study the phenomenon of interest, suggesting that the observed findings differ to a certain degree from reality. This eccentricity in the accuracy of findings is caused by the unique yet differing characteristics of each participant in the sample. Additionally, the level of sampling error present in a study is affected by both the sample size and sampling technique chosen. As the sample size increases, the extent of the sampling error decreases, while an apt sampling technique that aligns with the study's objectives must be selected. In order to quantify the sampling error in quantitative research, variables like the LOC, standard error, coefficient of variance and p-values can be utilised (Etikan & Babatope, 2019).

Non-sampling errors comprise all types of errors except for sampling errors that occur in a study. Firstly, a researcher should clearly describe their sampling frame before collecting data, ensuring that they define and select the correct type of person to provide the necessary information. Otherwise, the inability to include a key part of the target population or a sufficient number and variety of participants with the required attributes may result in a coverage error that causes the data to be faulty or imprecise (Etikan & Babatope, 2019; Ali, 2014).

Furthermore, measurement errors may arise from not describing the research instrument clearly enough, resulting in sample participants providing misinformed answers due to ambiguity or poor instruction. For instance, a question in a survey may be stated ambiguously or in such a way that it is unclear or too complicated for participants to understand, causing them to give inaccurate responses. Generally, well-phrased questions result in good quality responses. Alternatively, participants may also be responsible for errors in the data when leaving out questions or giving poor-quality responses because they are tired, disinterested or moody. A researcher should always follow up with the respondents in the case of a question being omitted (Etikan & Babatope, 2019; Ali, 2014).

Once the data is collected, those who input and synthesise the data on computers may make mistakes when digitising, cleaning, processing, interpreting and presenting the data. For instance, data errors could be made when inputting an incorrect digit, following the wrong statistical approach or misunderstanding the implications of the raw data and thus presenting it incorrectly (Etikan & Babatope, 2019; Ali, 2014).

2.6 The existing status of transportation in South Africa

2.6.1 Background

While this section does not directly relate to either study construct, it intends to provide context to the study by investigating the current status of public transportation development in South Africa. With this context, the researcher can understand the existing transportation circumstances in South Africa as well as objectives set by the South African DoT to develop PT, allowing its study's findings to contribute to these objectives so that solutions are applicable to the local South African context.

2.6.2 Introduction

South Africa's national government considers transportation to be the "heartbeat" of economic growth and social development (Department of Transport, 2013), viewing it as a basic human right among other vital social services like education and healthcare (ANC, 1994). It has been shown that households in South Africa spend approximately ten times more on PT than on education, equivalent to approximately two-thirds of their income (Letebele et al., 2009; Mthimkulu, 2015).

If the allocation and improvement of PT services carries such importance, one could ask why action is not being taken to secure sustained funding and invest into transport strategies that more consistently and effectively serve the needs of South Africa's growing customer base (Mthimkulu, 2015). In 1994 after South Africa declared its independence as a democratic country, the leading political party (the ANC) declared that a transport development programme would be launched to reconstruct and reorganise the operation of South Africa's transport system. Among its many intentions, this programme aimed to allocate acceptable PT services at off-peak hours, ensure security presence during late peak hours and consider allocating additional subsidies for citizens with limited incomes, such as students and pensioners (ANC, 1994).

However, it seems action taken to achieve these aims has been inadequate. Today, South Africa's PT system remains burdened by unresolved issues such as dependence on private transport and the lack of alternative travel modes to redirect private vehicle users, resulting in peaking road congestion and persistently high road accident rates. Scholars believe these problems arise due to the lack of integrated transport, periodic communication between travel modes and central transport hub development, which continue to detrimentally impact the health of South Africa's developing economy as long as they are left unaddressed (Mthimkulu, 2015; Schoeman, 2014).

2.6.3 Description and roles of transport modes

Today, private cars (37%), NMT (25%) and PT services (38%) are the main transportation systems being used in South Africa, each being operated by a specific set of transport stakeholders and possessing its own roles and strengths in serving the transport network (TDA, 2014; Walters, 2014). PT services are further comprised of rail transport (10%), BRT (20%) and MBTs (70%) (TDA, 2014; Walters, 2014).

Due to its relatively low service cost, rail transport is used mainly by commuters who cannot afford other travel modes, forming the backbone of South Africa's PT system due to its ability to serve transport corridors with a high passenger capacity (Development Bank of Southern Africa, 2006). Commuter rail services are being provided by Metrorail (a national state-owned company) and operated by PRASA on a provincial scale (Walters, 2014; Development Bank of Southern Africa, 2006). Infrastructural upgrades such as rail modernisation programmes are currently underway to improve and optimise the operation of this network, while new train stations are under construction so that the rail network can serve greater volumes of passengers (Walters, 2014; TDA, 2014).

Conventional BRT services are known to serve transport markets in both the suburban city area and townships where commuters are more reliant on PT services (City of Johannesburg, 2018). Bus services have the potential to be a catalytic system for transporting commuters and are currently being provided by businesses like Golden Arrow and Sibanye on provincial scale, while also being operated by Rea Vaya and MyCiti on a wider metropolitan scale (Walters, 2014; City of Cape Town, 2012). These services are being optimised through route extensions and planning new routes (TDA, 2014). The bulk of urban commuters in South Africa make use of MBT services, an informal paratransit mode that is operated on a metropolitan scale (Fourie, 2003; Walters, 2014). MBT services are marginally unsubsidised by the government (TDA, 2014).

2.6.1 Transport projects in South Africa today

The Department of Transport (DoT) are currently underway with a series of transport development projects as viable solutions to the provision of intermodal PT. These commitments aim to create employment opportunities and better the conditions of the road environment, by implementing high quality projects and improving the design and maintenance of local roads (Department of Transport (RSA), 2020a). Fresh, innovative techniques are becoming increasingly desirable to enable the development and management of high-quality PT networks (Department of Transport (RSA), 2020b). It also seems that transport forums for stakeholders to express their views and consistent stakeholder consultation in all transport-related endeavours are becoming a societal norm (Department of Transport (RSA), 2020c).

In 2007, the Moloto Rail Corridor Development project was introduced with the primary objective of re-establishing passenger rail transport as the backbone of an integrated PT system. By utilising advanced rail infrastructure technology, this project has the potential to stimulate economic development on the periphery of the rail corridor and address transport challenges to ensure PT services are affordable, safer to use, operate more efficiently and are more equipped for modal integration (Department of Transport (RSA), 2020a).

However, in 2019, the Minister of Transport Fikile Mbalula reported that the implementation of this project could only proceed once funding has been prioritised and secured by the government (Maqhina, 2019). Later that year, the Minister reported that the project's funding had been disapproved by the National Treasury due to its unaffordability, claiming the project would be unlikely to generate the benefits suggested in the feasibility study. In addition, it was uncovered that the project delivery was promised over a period of 12 years primarily to manipulate the emotions of citizens and accumulate votes for the upcoming election campaign, wasting R18 million in citizen taxes (Mabhena, 2019). This suggests that the reason PT development initiatives in South Africa are unsuccessful, regardless of their positive intentions, is because political agendas interfere with the crucial responsibility of PT service provision.

BRT development is also being made a greater priority in transport development, since these services function to connect the transport network to various city areas and transport large numbers of people. As part of this initiative, the intention is to make BRT services available within 500 m of the living location of most city citizens by 2020. Existing bus and MBT operators are to be fed into the PT system and form part of a long-term contracts with local municipalities, ensuring that their operations are regulation and aligned with modal integration (Department of Transport (RSA), 2020b).

BRT infrastructure such as fare payment systems and stations are being maintained using public-private partnerships (PPP), in which private operators are responsible for the management of BRT services and offering services on a long-term basis. To ensure BRT services are affordable, fare payment is being managed by means of a smartcard system, where fares are paid per kilometre. For example, the Rea Vaya smart card system allows commuters to travel simpler and safer, since fares are uploaded and paid digitally (Department of Transport (RSA), 2020b).

The South African government has established a year-long transport program that aligns with global initiatives like the UN Decade for Action for Road Safety and the Millennium Development Goals. As a main objective of these initiatives, the DoT plans to half the number of road fatalities in South Africa by 2020, considering the road safety of pedestrians, passengers, scholars and drivers (Department of Transport (RSA), 2020c).

2.6.2 Integration issues and the premise of the Gautrain

Due to poor integration of paratransit services into a multi-modal transport system, commuters are every day inconvenienced by having to pay fares through the different media and management structures, having the potential to become far simpler and more efficient when these modes collaborate in a single, complementary transport system (Schalekamp et al., 2007). Alterations in a mode's fare system impacts the entire business model as well as the relationships between commuters, labourers and modal operators, standing as an explanation for the resistance to such an integrated PT fare system. Failure to implement suggested PT initiatives, regulations and policies also limit the objective of integrating these transport systems (Department of Transport, 2021; Turok & Watson, 2001).

The Gautrain system in Gauteng Province stands as a living example of what is possible in a PT system when willing political support is applied to driving and implementing plans and policies (Walters, 2004). The Gautrain system is Africa's first state-of-the-art rapid rail and BRT service that was introduced to satisfy future travel demands as a result of population growth, with the hope of stimulating economic growth through tourism promotion and job creation (Gautrain Management Agency, 2018a, b).

The Gautrain network is present in five South African provinces and connects the main economic hubs Johannesburg and Pretoria, intending to rejuvenate these hubs by reducing traffic congestion and in turn promoting smart city standards through integrated land use (Mthimkulu, 2015; Gautrain Management Agency, 2018a, b). Airport passengers are also served through a link to the OR Tambo Airport (Mthimkulu, 2015). Thanks to fulfilling the suggested transport development plans, this project is envisaged to promote economic growth in South Africa and inspire the long-term sustainability of major cities (Mthimkulu, 2015), aiming to promote the mobility and accessibility of the transport network and support resource-based economic and rural development (Gautrain Management Agency, 2018b).

According to Pillay (2001), the current policies and strategies relating to PT in South Africa are in dire need of re-evaluation. Instead of designing and implementing a whole new system, it is important to rediscover the elements of the existing system that are functioning effectively and find what opportunities they hold for economic growth and sustainable transport practises (Mthimkulu, 2017). Infrastructure development in South Africa should focus on unlocking economic opportunities, promoting job creation (given insufficient citizens have access to stable work opportunities) and addressing socio-economic needs, such as the financial capabilities of commuters. The priority of the development should be aimed at encouraging strong leadership and active citizenry to strengthen commuter's accountability, thus uniting citizens around a common programme and boosting economic growth and subsequent investments (Schoeman, 2014).

2.6.3 Developing South African transportation services

Local PT services become increasingly less available when the provision of these services remain inefficient and of poor service quality, meaning PT is less capable of providing for commuter travel demands. Therefore, infrastructural improvements and a certain degree of reform in services should be undertaken to support and enhance the operational efficiency of PT, so it is more capable of transporting passengers (Ardila, 2008).

South Africa can achieve the same level of inclusive transport management as developed countries by establishing local transport authorities as greater means of modal support and regulation. This allows transport operations to be coordinated locally so the travel needs of citizens can be met more specifically. Further, the process of planning transportation development should be carried out more deliberately to yield a variety of transport services and facilities that are properly coordinated and integrated. It would be simpler to determine the necessary transport needs and policies by constructing a more collaborative, democratic process: another effective way to respond to citizens' travel needs (Thomas, 2016).

However, implementing permanent transport policy changes may be difficult. For instance, in South Africa, new transport infrastructure or policies to improve PT service quality are often introduced, but not carried out. This is often due to a lack of leadership to support the system's growth and drive the project to completion (Poliak et al., 2017). Therefore, it may be simpler for cities to undergo trials to evaluate the effectiveness of their plans or apply changes suggested by new policies in an incremental way (Mitchell, Claris & Edge, 2016; Shaw, 2006). Incremental development should be focussed on high-demand corridors that influence a large volume of passengers (Shaw, 2006).

Mthimkulu (2017) states that it is vital to reconsider what the actual problems are behind PT challenges, so that plan and strategies can be executed differently. The focus should be redirected to rediscovering the value and potential fundamental components that existing systems hold, instead of developing brand new systems that are expensive and not satisfying the actual problems. It is recommended that PT systems are developed for extreme PT users (i.e. disabled persons, the elderly and lower-income commuters), thus removing the restriction of only some income groups being liable to use travel services. Effective, well-operated and sophisticated PT systems can be provided once the political will of government officials and national leaders is aligned with suggested plans and policies (Mthimkulu, 2017).

This view is supported by Pillay (2001), stating that discussion between stakeholders such as transport planners, engineers, urban designers and politicians would be the most effective in generating feasible alternatives for a sustainable, efficient PT system (Pillay, 2001). To build an integrated transportation system, governments should anticipate transport infrastructure interventions and foster a holistic attitude towards transport provision (Mitchell, Claris & Edge, 2016).

2.6.4 Learning from public transport success in developed countries

As a reliable reference, middle-income countries have succeeded in their PT development schemes by cultivating a pro-active mindset towards creating quality integrated PT systems. This pro-active transport approach needs local governments to intervene in the provision of infrastructure, regulation of private operators and monitoring service provision (Shaw, 2006). Infrastructure interventions mean investing in transport infrastructure directly supporting PT service improvements, as systems with a high customer turnover require a minimal subsidy to operate independently (Shaw, 2006). A need exists to regulate the actions of private operators, allowing operator behaviour to be managed locally at a city level (ITDP, 2004).

Importantly, the strategies applied by high-income countries to support the evolution of PT systems and improve road safety cannot simply be taken and applied by low-to-medium-income countries (LMICs) like South Africa. LMICs need suitable solutions that satisfy problems that originate from local conditions, so it is crucial that priorities are identified from local circumstances and strategies are developed to address them (Wijnen & Stipdonk, 2016).

2.7 Challenges limiting sustainable transport development in South Africa

2.7.1 Introduction

Now that context is created on the status of public transportation in South Africa, this section zooms in on the variety of challenges that limit the sustainable, collaborative and integrated development of PT services in South Africa. As such, the challenges discussed here become indicators for where this study's findings can contribute to PT research in order to ultimately resolve these issues, so that the design and development of a holistic, balanced PT network can prevail.

2.7.2 Background

For many years, the true potential of South Africa's PT system has remained limited due to the provision of inefficient and highly subsidised transport systems (Mthimkulu, 2015). During the Apartheid era, South African transport systems were designed with the main objective of transporting labour to and from the workplace (Khosa, 1995). Today, after Apartheid, South Africa seems to have remained a divided society where development and integration of PT systems have remained inefficient (Mthimkulu, 2015; Walters, 2014). As a result of the poor management of PT service provision, racial division and government control, locations of transport infrastructure were and today remain a site where commuters desperately reliant on these services recklessly express their built-up tension and frustration (Khosa, 1995).

2.7.3 Segregation and mobility-related exclusion

The division of the South African society seems to be a result of spatial and political segregation, unequal access to transport infrastructure and the planning of housing developments away from areas of high economic activity (Mthimkulu, 2015; Walters, 2014; Schoeman, 2014). South Africa's PT system follows the same network pattern as it did before 1994, characterised by a combination of highly regulated services that are primarily owned by the government, some of which are informal and unsubsidised (City of Johannesburg, 2018). Due to this lack of spatial integration, the inclusive development of travel modes as a unified system has not yet progressed to the status that is planned or desired, meaning PT services are often unreliable and offer low service quality (Schoeman, 2014).

Such segregation results in low population densities around areas with PT development, presenting dependent commuters with ongoing economic challenges (Department of Transport, 2021). Most population growth in low-income residential areas takes place on the perimeter of the PT network, meaning citizens living far from PT hubs are faced with increased travel time and travel costs (TDA, 2014; Boraine et al., 2006).

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The concept of 'mobility-related exclusion' defines the process by which citizens are excluded from participating in economic and social aspects of the community as a result of limited accessibility to opportunities and services (Kenyon et al., 2002). Unless jobs are created nearer to the transport network and facilities hosting these residents do too, the provision of transport services is likely to remain uneconomical and pose financial issues to citizens and local municipalities (TDA, 2014).

As such, a key challenge that must be addressed in South Africa is the disparity in the provision of affordable, reliable PT services for commuters in the lower-income range who are dependent on the system to travel and earn a living (Mthimkulu, 2015). Mobility-related exclusion dilutes the potential of the South African society to transform racial, gender and social inequalities that remain (Kenyon et al., 2002), meaning the geography of the divided society that resulted from Apartheid's political influence must now be restructured and reorganised to better and more fairly serve the transport population (Thomas, 2016). Further challenges in coordinating transport services and responsibilities result when several sections of government participate simultaneously in the planning and design of transport infrastructure (Lucas, 2011).

In 2000, the South African government released a draft form of the National Land Transport Transition Act (NLTTA) with the objective of reversing the spatial influence of Apartheid on land use and the transport network. Unfortunately, the NLTTA planning process fell short of addressing the separation that existed between travel modes as well as the MBT preferences of most commuters (Shaw, 2006), emphasising the fragmentation of PT services that operate without integrated ticketing, scheduling and marketing (Mostert, 2011). The Act also failed to address the fact that, in high demand corridors, bus and rail services should carry the largest proportion of commuters due to having a higher passenger capacity (Shaw, 2006).

2.7.4 Lack of modal integration

Commuter dissatisfaction with PT service provision in South Africa is explained by the inadequate quality of services and the lack of modal integration (Shaw, 2006). Poor service quality is characterised by issues like lack of safety and security, overcrowding, expensive service charges and poor-quality transit stations, in addition to rail transport either not being available or too far away to access (Shaw, 2006; Barrett, 2004). Some commuters are also not able to access regular BRT or MBT services, while the road network may not extend to their preferred destination (Barrett, 2004).

Shaw (2006) believes these issues clearly indicate a transport environment that lacks in conductivity to make transfers simpler and safer, while highlighting the lack of integration of the rail with its feeder modes. Rail services continue to receive a deficit subsidy to cover its operational expenses. This runs to risk of rail services becoming overly dependent on subsidies that it loses innovation to generate funds internally. Therefore, the rail transport market value plummets when receiving a subsidy less than necessary to sustain its services (Shaw, 2006).

There seems to almost be a deliberate attempt by various modes to avoid modal integration, likely because of the complications it would present for their payment systems and operational freedom (Brand South Africa, 2015). It seems formal and informal transport modes continue to compete without the thought of integrating their services, failing to present more effective standards of service delivery. This emphasises the need for formal modes to introduce and follow performance objectives for their transport service delivery (Shaw, 2006).

This lack of integration is also believed to result from an overall lack of strategic and holistic thinking on how to interlace multiple modes of transport fairly and efficiently into a single, cooperative network (Van der Westhuizen, 2007; Mostert, 2011). More specifically, extended route distances between labour sectors and townships illustrate how BRT services lack integration with other modes (City of Johannesburg, 2018), while BRT continues to be challenged by the necessity to integrate their services and routes with the MBT industry (Walters, 2013). Commuters are dissatisfied with MBT services because of the lack of roadworthiness of their service vehicles and the degree of careless risks taken by MBT operators to maximise their passenger turnover (Shaw, 2006). Municipalities first need to collaborate with and then redistribute MBT drivers to BRT vehicles in order to exercise BRT development, suggesting challenges exist with negotiating and reassigning MBT drivers without conflict (Walters, 2013).

2.7.5 Lessons learnt from Lombard and Hugo (2002)

Lombard and Hugo (2002) investigated the opinions and travel mode preferences of commuters in Cape Town with a two-phased study. Phase 1 incorporated the opinions of captive, long-distance PT users from Cape Town and Mitchell's Plain, and Phase 2 focussed on private vehicle users living nearby rail services. Many commuters claim that PT service providers remain indifferent towards their travel needs and complaints. This is likely because travel modes operate on minute profit margins, forcing them to work at an increased rate to earn a decent salary (Lombard & Hugo, 2002).

Phase 1 results noted that commuters had no alternative to their original mode of transport due to the alternative modes being too expensive, having to walk too far to get to the mode and being inconvenienced by extensive waiting times. Almost half of the rail users in the sample share that when the trains are unavailable, they have no other means of getting to work. These commuters clearly reflect those who are presently held captive by inadequate PT systems and remain financially burdened by the unethical, unreliable actions of these systems (Lombard & Hugo, 2002).

2.7.6 Issues with the Gautrain project

In a study evaluating the impact of social media on changing commuters' perception of using the Gautrain, Musakwa (2014) investigated the attitudes of commuters reflected in social media posts. The posts emphasise that due to the elevated expense of using the Gautrain service, such a system prioritises only wealthy commuters in the high- to middle-income range in the distribution of public funds (Musakwa, 2014; Mthimkulu, 2015; Thomas, 2016). The speedy shifts in the earnings of the middle-income class are believed to be a reason behind the insufficient use of South Africa's PT services (Shaw, 2006).

Additionally, the objectives held by the Gautrain rapid system focusses only on shifting private vehicles from the road to the rail (Oxford, 2013), without carefully considering how its rail and bus services would integrate with the transport strategies and plans of nearby municipalities (Thomas, 2016). The Gauteng Province chose to manage and implement the project without support from local municipal governments usually involved in PT infrastructure planning, and without consulting the public in the design process, continuing with the project's execution without considering other more affordable transport alternatives like BRT (Thomas, 2016).

Scholars investigating the financial aspects of the Gautrain project discovered major flaws in its cost-benefit analysis, noticing that the consumption of public funds exceeded the benefits the systems would offer to Gauteng (Van der Westhuizen, 2007). This is likely because of the enormous cost overrun in the project. Initially, it was estimated that the Gautrain project would cost R7 billion to construct, but ended up costing R30 billion (Thomas, 2016); as a comparison, the construction of the first two phases of the Rea Vaya BRT system was estimated to cost R3 billion (City of Cape Town, 2012). The environmental benefits that were expected from the project also don't exist, since pollution generated by coal power stations to operate the Gautrain network would just be shifted to another province (Thomas, 2016); Gautrain's development was found to have a neutral pollution emission impact (Bohlweki, 2002).

It seems that the attempt to present new PT infrastructure with a modern appeal plays a vital role in the strategic transport planning of local governments, likely because more customers would be attracted to the perceived sophisticated of the transport service. As such, Thomas (2016) believes that the only reason a project with so many fundamental flaws would go ahead is because the government at the time desired to leave behind a legacy, this while the need to provide safer, more reliable transport to dependent citizens was a far greater national priority (Thomas, 2016).

2.7.7 Holistic design thinking

The issues arising from the Gautrain case study are symbolic of how limited current solutions are to solving more prevalent transport problems in South Africa. It seems solutions offered are often not well-enough linked to the actual problems that need addressing. Therefore, it's crucial to reconsider what the fundamental issues are with PT in South Africa and offer increasingly appropriate solutions that prioritise the travel needs of captive commuters, especially the majority of those living below the poverty line (Oxford, 2013; Mthimkulu, 2017; Thomas, 2016).

South Africa must also determine a means by which a more consistent inflow of funding can be generated internally, instead of continually receiving economic support from the government via transport service subsidies. This form of funding implies transport services are more dependent on financial support, taking away from our country's ability to find creative means of generating more funds internally. A greater inflow of independent funding is needed to support the policy implementation and enhance the quality of transport infrastructure, while enabling modal integration (Shaw, 2006).

A reliable, consistent and efficient PT system can indeed be moulded by shifting the focus of the system to the 'extreme' user (those most harshly affected by poor service provision) and finding a way to reduce their travel costs, thus providing captive travellers with the opportunity to travel at affordable rates (Mthimkulu, 2017). Infrastructural development of PT is another approach to mould this desired system, the aim of which is to integrate the location of human settlements with economic development. This development also applies a variety of techniques to design, plan, construct, operate and maintain all PT modes in an integrated way (Schoeman, 2014; Pillay, 2001).

2.8 Competition between travel modes – beneficial or not?

2.8.1 Background

As an extension of the previous section, one major challenge limiting South Africa's PT development is discussed in this section, namely the destructive, uncoordinated competition between travel modes. Given that the study's research methodology focusses on collecting data from users of rail-, MBT and bus transport services, this section provides a background on whether such competition can be beneficial or not to a country's transportation development. In turn, this ensures the study's findings can be correctly interpreted and effectively applied to South Africa's local context by harnessing the potential benefits of modal competition.

2.8.2 Modal competition

Competition between transport modes on the road can be utilised as a way to manage the transport network, highlighting and addressing the importance of service provision and thus suggesting increased value of services (Van de Velde & Westeneng, 1994; Cripps & Ireland, 1994). The objectives for a competitive transport environment must be clearly and factually presented and the executive power to manage this environment must be assigned to local authorities (Chen et al., 2016).

2.8.3 Unique roles of travel modes

Every mode in an urban transport network has a very specific role to play, serving different travel corridors and passenger volumes (Department of Transport, 1998). Cities have the potential to become more sustainable when transport authorities invest in higher quality PT systems (particularly rail) and provide suitable urban environments for pedestrians and cyclists (Kenworthy, 2006). This is because non-motorised modes like walking and cycling are the most sustainable ways to travel (Newman & Kenworthy, 1984).

2.8.3.1 Rail

Rail transport is responsible for serving high-volume travel corridors with more than 40,000 passengers per day per direction (Department of Transport, 1998), therefore playing the crucial modal role of ensuring elevated passenger ridership over greater trip distances (Kenworthy, 2006; Hwang, 2001). Thanks to its high travel speeds, reliable services and dedicated transport corridors, rail transport is known to be more competitive with automobiles (Pucher, 2002; Newman & Kenworthy, 1999). As a reliable reference for the potential role of rail transport, the rail network in Seoul, South Korea, transports 8.4 million commuters each day, remaining the backbone of Seoul's trunk-and-feeder-type PT system (Kim & Rim, 2000; Seoul Development Institute, 2003).

Alternatively, service delivery in high-demand South African rail corridors is in dire need of innovation and revitalisation (Shaw, 2006). To do so, it is recommended that rail networks in cities are isolated from national rail companies and that local transport authorities are established to promote fairness and effectiveness in the provision of rail transport (Shaw, 2006). A more dedicated customer focus can result from incorporating the private sector in rail transport services, particularly by moulding PPP models that encourage improved innovation, reliability and proficiency in service delivery (Gomez-Ibanez, 2004; Shaw, 2006). In addition, the quality of rail assets (both fixed and movable) would also be enhanced (Shaw, 2006).

2.8.3.2 *Buses and minibus taxis*

Road-based PT modes like BRT and MBT possess a dedicated transport infrastructure with higher priority than automobiles, serving medium-volume corridors with 10,000 – 40,000 passengers per day per direction (Department of Transport, 1998). The upgrade and construction of BRT express service is far cheaper than the costs incurred from metro rail developments and can be implemented far more quickly (Pucher et al., 2005; City of Cape Town, 2012; Seoul Development Institute, 2003; Kim, 2005), known to be the most affordable method of offering expanded PT services to address rising commuter travel demands (Pucher et al., 2005).

BRT services are believed to be a remedy to the current mobility-related exclusion of South African commuters since it more effectively connects people to their location of employment, removes unnecessary passenger transfers and adapts more flexibly to variations in future travel patterns (City of Cape Town, 2012; Kim, 2005). Integrating BRT with the rail is a vitally important step to create a successful, seamless PT system (Seoul Development Institute, 2003). Of the many travel modes that operate in South Africa's competitive transport network, MBTs possess an effective business modal that reach potential passengers simply and conveniently. Other modes can definitely learn from the informal way in which MBT networks meet customer demands by providing a frequent, accessible and flexible transport services (Walters, 2014; Mthimkulu, 2017).

2.8.4 Destructive modal competition

Regulative authorities are concerned that harmful competitive practises may result when introducing competition to a network, since there exists a risk of losing control of the system (Van de Velde & Sleuwagen, 1997). The functioning and overgrowth of the MBT industry illustrates this concern perfectly in South African context, functioning as an informal PT mode that doesn't follow timetables, rapidly adapts to commuter demands (Khosa, 1998) and relies heavily on government transport subsidies (Fourie, 2003). Importantly, only cities practising proper control over the enforcement and regulation of transport service operators have found success in transport infrastructure upgrades. The South African government's inability to effectively regulate the detrimental competitive practises of these informal modes has been a

reason why South Africa has struggled to develop PT systems and encourage increased ridership (Shaw, 2006).

At the beginning of each day, owners of MBT vehicles set challenging minimum target earnings for their drivers, implying drivers earn any amount in excess of this target (Walters, 2014; Khosa, 1998). Therefore, it seems MBT operators are often forced to take risks on the road and ignore traffic regulations to transport more customers to their destinations at a faster rate to maximise their daily earnings (Walters, 2014; Khosa, 1998). MBT drivers often practise unsafe driving and behave competitively against other modes to accumulate more customer fares (Walters, 2014), concerned that they will earn insufficient income and potentially lose their jobs (Walters, 2013).

As a result of these concerns, MBT operators often meet to form alliances against formal travel modes and negotiate travel route territory (Walters, 2013). While also competing amongst themselves to maximise their earnings, MBTs compete destructively with high passenger capacity modes like rail and BRT that use the same travel routes, given these services absorb potential MBT customers and affect the revenue that MBT drivers could have been generated (Fourie, 2003; Walters, 2014; Mthimkulu, 2015). MBT competition is the most excessive along rail transport corridors, likely because the rail absorbs a large volume of customers due to its high passenger capacity role in the network (Shaw, 2006).

Similar competition between modes of transport can be chaotic and detrimental to the health of the PT system, so regulation based on assigning rights and spatial limitations is suggested as a solution (Van de Velde & Sleuwagen, 1997). In the case of high-demand transport corridors that are dominated by automobiles and MBTs, opportunities for modal integration with PT services can be achieved by negotiating and collaborating with the operators of this service (Shaw, 2006).

2.8.5 Importance of modal competitiveness

Although there may be a need to dissolve competition between PT modes altogether to create a connected, collaborative PT system, some researchers believe modal competition is the key to stimulating a modal shift from private vehicles to PT. Poliak et al. (2017) found that it was necessary to increase the competitiveness of PT modes in developing countries to attract more passengers towards PT services and prevent the adverse consequences of a shift towards private transport from manifesting (Poliak et al., 2017).

Competition between modes was found to be more important in developing countries, who lose market share for transport revenue far quicker than developed countries, and whose infrastructures are not ready to share private transport in the transport market on a national level. Monitoring the modal split of travel modes in the network was thus found to be necessary to ensure an efficient PT system (Poliak et al., 2017).

2.9 Essential criteria for a human-centric transport environment

2.9.1 Introduction

Directly relating to a main study construct, this section considers how a person can interact effectively with the urban transportation environment through the provision of human-centric services and infrastructure design. Herein, the incremental shift towards HCD and universal design (UD) is discussed and criteria relating to human-centric service delivery is presented to understand which criteria are most applicable to favourable, successful HCPTD. This content is used to inform the researcher about how HCD can be infused into South African PT design, thus being utilised during both research phases and the study's final discussion.

2.9.2 The interacting urban environment

It is believed that urbanisation presents cities with many socio-economic opportunities, often unlocking financial resources to fund large-scale projects for the development of transport infrastructure (Mitchell, Claris & Edge, 2016). The urban environment is made up of two interacting parts, namely **human** needs (including personal and social considerations) and **ecology** needs (for instance, biodiversity and water treatment systems) that form the backbone of urban infrastructure development (Yang et al., 2019a).

Transport can be seen through a twofold perspective. On the one hand, as a result of noise pollution, unhealthy air quality and being physical inactive, transport can be the cause of poor health. On the other hand, transport can also be the cure to good health by encouraging active travel that improves air quality for all. Reshaping the way our transport systems operate can thus promote an improvement of the economic and social aspects of our lives (Mitchell, Claris & Edge, 2016).

2.9.3 Solutions to mobility issues

Mobility issues can be addressed by funding smart PT infrastructure and supporting a greater variety of more sustainable travel choices, such as walking, cycling and rapid transit. Additionally, sustainable systems and smart cities can also be created by promoting transparency and knowledge sharing amongst transport stakeholders to generate fresh ideas as solutions to existing issues (Toderian, 2015).

Various transport functions should be operated more commercially as opposed to a governmental social service, so that private companies can manage modes more effectively as a commercial product, thus allowing a constructively competitive market to form (Khosa, 2001). Mostert (2011) advises that a special purpose transport agency, with a holistic perspective on PT and carrying a reputation of transport

improvement, should be instantiated to monitor and manage the movement of all formal transport service operators (Mostert, 2011).

Solutions are also required to promote the harmonisation and regulation of modal services in the transportation network. For instance, service operators could be required to satisfy specific pre-conditions of service regulations prior to being included in a transport system (Hook, 2005), or operator licenses could be linked to each mode's assigned route to mitigate and regulate harmful competition between travel modes (ITDP, 2004). Transport authorities should also monitor modal service provision by ensuring a multitude of different service operators are included in a holistic way; instantiating PPP contracts have become the norm to promote the development and modal integration of these networks (ITDP, 2004).

Lucas (2011) offers five recommendations to dissolve mobility-related exclusion of the lower-income community in South Africa. The cost of MBT services should either be lowered or subsidised, while the operation and fare system of this mode should be properly regulated. The overall provision of PT service should be enhanced and of a higher quality, including improved security and policing at transit hubs and waiting areas. Affordable housing should also be made available at a closer distance to important activities like education, healthcare and employment (Lucas, 2011).

2.9.4 Shifting to human-centric design

Decision-making in transport provision is becoming more oriented around the needs, perception, consultation and satisfaction of passengers (Mitchell, Claris & Edge, 2016; Ko & Stewart, 2002), focusing more on a commuter's basic desire to travel from one destination to the other in the most seamless, affordable way (Mitchell, Claris & Edge, 2016). It is no wonder smartphone applications like Google Maps™, Citymapper™, Waze™ and Uber™ are becoming an increasingly important component of mobility in urban cities, since they exhibit excellent user-centric features that have successfully engaged with commuters, thus being perceived to make their travel journeys faster and more coherent (Cohen et al., 2017; Mitchell, Claris & Edge, 2016).

This trend in digital mobility application use induces a need to optimise these services such that they more rapidly respond to the demands and travel habits of commuters. This can potentially be addressed by a user-centric design (UCD) process: a synonym for HCD (Cohen et al., 2017). Transport operators are starting to utilise the potential of UCD in PT to develop products that make commuter interactions and journeys more streamline, accepting that research in the field of transportation design is vital in order to enhance a commuter's travel experience (Innovation Team, 2015; Cohen et al., 2017; Rail Safety and Standards Board, 2016). For example, transportation products can be developed to minimise the number of service queries received from commuters, while the data produced by passengers on digital mobility applications can be

sold to transport sectors like marketing and advertising to predict future fare prices and earn an additional income, further supporting PT development (Innovation Team, 2015).

Much can be learnt from the findings of Cohen et al. (2017), which focused on investigating mobile user needs in the context of PT in more developed countries. The reliability of travel data was noted to be key when attempting to build trust with commuters, also largely affecting a user's desire to make use of particular journey planners. Any travel information provided should be suitable to the travel mode a commuter is using as well as modes they prefer using on a regular basis and should only be provided when necessary. Users require that the design of mobile apps is tailor-fitted to the variety of user needs as well as groups of users who make use of these travel services, also expressing their challenges when it came to modal interchanges (Cohen et al., 2017).

Mitchell, Claris and Edge (2016) shed light on this user-centric transport nature by using the term *human-centred mobility*. A working definition of this term is a system which places the user at the centre of design thinking and aims to benefit both passengers and operators with the provision of organised, durable transportation strategies. The authors believe a high-quality human-centred mobility system is characterised by being user-centric, system agnostic (allowing swift transfer between different travel modes) and accessible to support a thriving, evolving city. Furthermore, these systems enable seamless, door-to-door trips via integrated ticketing systems and real-time travel information (Mitchell, Claris & Edge, 2016).

2.9.5 Smart city characteristics

While there may be other important roles in defining a smart city (such as sustainability, infrastructure and economy), this definition aligns well with the context of this study, as it puts people and the promotion of their wellbeing at the core of the smart city concept (Lara et al., 2016) – the basis of the HCD principle (Design Kit, 2021; DC Design, 2017). For this reason, it can be argued that a HCD approach could play a key role in satisfying commuter travel needs and positively transforming the way a city operates as a collective whole.

Of the four domains that define a smart city, one domain is defined as the "human infrastructure", served by promoting the humanity and "human smart" essence of its inhabitants (Nam & Pardo, 2011). The human infrastructure domain of a smart city can be enhanced by involving citizens in the joint design and implementation of services within the city, through encouraging and allowing citizens to participate in the construction of infrastructure as well as gathering and utilising continual feedback on its effectiveness in meeting their needs. Such collaboration is defined as *quadruple helix model partnership*, which is elicited by PPPs with the local community and academic institutions (Rizzo et al., 2013). As such, it is important that

citizens and institutions who are knowledgeable of the history, culture and probable future of the city work together in order to properly design for its unique characteristics (Lara et al., 2016).

Furthermore, this domain is also served by providing an urban environment where citizens are given the opportunity to live creatively, explore new possibilities and savour a high quality of life (Streitz, 2011). To cultivate such a level of connection of citizens with their city, leaders must discover means to connect with people such that they create a shared vision for the city they wish to live in (Lara et al., 2016) and encourage a lifestyle that aligns with the values and culture of its people (Ballas, 2013).

To make a city and community "smart", all initiatives must comprise of an iterative, user-centric process where the community is involved in design and development (Lara et al., 2016), and all innovative solutions (including technology, infrastructure and transportation) are offered with the central goal of serving the needs of the city and its people - this will ensure the city is both highly independent and economically sustainable (Yigitcanlar et al., 2016). Furthermore, Ballas (2013) attests that the wellbeing and inherent contentment of citizens is the central goal (but also main trial) of making a city "smart", stating that the promotion of these aspects should be as important to city planners than the technological, engineering focus of their design (Ballas, 2013).

2.9.6 Universal design considerations

It is likely that infrastructural design criteria and passenger needs can be satisfied by means of adapting current designs to UD standards. These standards function with the vision of providing a transport environment where accessibility solutions benefit all commuters as integrated members of society, not just those with disabilities (Story et al., 1998; Aarhaug & Elvebakk, 2015).

Evidence has suggested that the provision of UD measures and optimised accessibility at transport hubs initiate an increase in passengers using PT services, thus supporting the intention of promoting increased PT service use (Ruud et al, 2008). There seems to be an excellent case for such design interventions, seeing as the social benefit of UD measures have been estimated to be twenty times greater than benefits generated from transport companies (Fearnley et al., 2009). It is important to note that consultation with commuters should be done as early as possible into the design process to avoid the UD system from being ineffective in meeting its stakeholder's needs (Herriott, 2011).

2.9.7 Considerations for enhanced service quality

Linking to the concept of HCD, a few factors are considered that influence service quality and encourage the choice of PT services over other alternatives. The provision of high quality, competent and flexible travel services coupled with professional support from staff is an essential factor in delivering passengers safely and comfortably on their travel journey (Aarhaug & Elvebakk, 2015). The choice to change travel behaviour

(and thus select PT over other alternatives) is linked to the personal norms of commuters and their attitudes towards travel alternatives (Ben-Elia & Ettema, 2011). This directly affects the likelihood of selecting a type of travel mode (Gärling, Fujii, & Boe, 2001). The decision to alter travel behaviour and avoid peak-time traffic is also strongly affected by the availability of travel information (Ben-Elia & Ettema, 2011; Ben-Elia & Shiftan, 2010; Ampt, 2004).

Therefore, a positive attitude towards sustainable modes of transport must be fostered in order for more commuters to make the choice of using PT instead of private vehicles. This is illustrated in the study of Ben-Elia and Ettema (2001), who found that a positive mind-set toward the use of PT and cycling discouraged driving and stimulated a modal shift towards NMT alternatives. Notably, the use of PT and NMT become a more attractive travel choice as travel time decreases (Ettema & Verhoef, 2006).

It seems the degree of accessibility that passengers have to travel services and transport infrastructure is a pertinent issue that engineers and transport professionals are attempting to optimise. This is considering that an elevated number of people will find it challenging to use PT services in the time to come (Samfunnsspleilet ne, 2004). Seeing as the intention of upgrading transport infrastructure is to attract more commuters to good-quality, sophisticated PT services and diminish the current dependency on private transportation (Cascetta & Carteni, 2012), improved accessibility to accommodate a variety of traveller needs is essential (Aarhaug & Elvebakk, 2015).

2.10 The road towards an integrated transport system

2.10.1 Introduction

Given that this study wishes to contribute to the integration of South Africa's PT network, this section discusses the context of PT integration, the process in which it is conducted and how to promote modal network integration. While these insights do not directly relate to any study construct, they are useful during the final discussion section of this study to make recommendations and conclusions on how the study's findings can be applied to support the integration of South Africa's PT network.

2.10.2 Background

Around the world, the elevated use of PT services is considered a solution to address rising transport demands in urban cities and better utilise the limited land space available (Ibrahim, 2003). As such, the benefits of integrated PT models are being investigated by cities and local service providers to expand the capabilities of more standard, limited PT models (Cottril et al., 2020). By promoting and developing more integrated transport solutions, concerns related to *transport poverty* in developing cities are being addressed, providing a remedy that makes transport services more affordable, accessible and mobile so that motorised transport can be used at a reasonable price to access important social activities such as employment, education and healthcare (Lucas et al., 2016).

In order to provide smooth and reliable transport services in South Africa, coordinating the strengths and roles of different travel modes is a vital step to take (Rivasplata, 2003). For instance, in the case of Singapore's PT system, rail transport forms the "backbone" of the system since it is characteristically safer, quicker, unaffected by road traffic movements and more convenient for commuters to use. This mode also has the highest transporting capacity of all modes, explaining why over 60% of the population utilise these services (Ibrahim, 2003).

The complementary operation of private-, public- and non-motorised transport would form a balanced, integrated transport system that promotes sustainable urban development. It is believed by researchers that creating such a unified system is possible by through provision of compatible timetables for all travel modes (Vuchic & Poulton, 2001; Saliara, 2014). Furthermore, the quality of transport services can indeed be sustained as long as service providers match the various customer expectations with the system constraints in a way that optimises the efficiency of PT services (Longo et al., 2016).

2.10.3 Defining integration

Integration is defined as an organisational process in which components of a PT system, including the network, infrastructure, tickets, fares, information and marketing, interact in a more efficient and cohesive fashion (Nosal & Solecka, 2014). Indeed, the integration of the built environment and PT infrastructure is known to be the first step towards ensuring sustainable development of cities (Varnelis, 2008). Notably, the key consideration when designing integrated systems is the actual versus perceived safety and security of the system (Fang & Zimmerman, 2015).

In an integrated system, all policies related to spatial planning and infrastructure investments are combined and all network travel information is provided, regardless of the travel mode (Nielsen, Nelson & Mulley, 2015). Scientists, policy makers and citizens should be involved in decisions to redirect transport policies to integrated network standards (Zellner, 2008). Making these policy shifts offers the advantage of minimising travel time and promoting continuous travel services, leading to improved travel conditions and service quality (Nielsen, Nelson & Mulley, 2015; Nosal & Solecka, 2014; Rivasplata, 2003).

2.10.4 The integration process

Integration of a PT system occurs in a variety of ways, including the integration of fares, information, schedules, the network and the management thereof (Ibrahim, 2003; Fang & Zimmerman, 2015). To promote the most logical means of doing so, this integration follows a three-step process.

2.10.4.1 *Step 1 – Organisational integration*

Organisational integration refers to a public authority that is assigned the responsibility to coordinate and organise the integration of transport services and standards. Initially, contracts between all transport stakeholders should be defined, guaranteeing their commitment to project performance. Then, clear objectives for the integration process should be identified by considering the expectations of passengers and operators and reviewing passenger attitudes illustrated in research results (Pucher & Kurth, 1995; Poliak et al., 2014; Rivasplata, 2003).

2.10.4.2 *Step 2 – Physical integration*

Physical integration refers to the planning, location and design of facilities, stations and interchanges in a network to improve accessibility and minimise spatial discontinuities in a system. Safe, swift and convenient transfer of passengers is thus enabled, in addition to responsible and equitable land use (Ibrahim, 2003; Fang & Zimmerman, 2015).

2.10.4.2.1 Infrastructure development

Physical integration includes making physical changes to a system, such as installing new infrastructure, the integration of new travel routes to improve coordination and the rearrangement of transfer points (Poliak

et al., 2017; Miller, 2004; Greiving & Wegener, 2003). Given the spatial influence of Apartheid on the efficiency of South Africa's PT network, White (2016) believes physical integration is crucial for the South African context.

This integration step includes the provision of physical transport transfer facilities such as stations and transport hubs that promote more hassle-free, efficient transfers between various travel modes (Ibrahim, 2003). Transfers between modes are often negatively perceived by passengers, so service providers should focus on removing unnecessary transfers and reducing the time and effort required when needing to transfer between modes, including minimising walking distances, providing safe and secure pick-up facilities and advertising features that present PT services as more cost-effective and enjoyable than private automobile use (Fang & Zimmerman, 2015).

2.10.4.2.2 Integrated information

Physical integration involves blending all factors relating to travel and real-time information of various travel modes in the transport system, supplying simple, understandable information relating to origin and destinations, trip planning, schedules and route selection. This information should be provided in a clear and simplified way at appropriate locations such as schools, stations and interchange point where people can find the travel information they need easily (Ibrahim, 2003; Fang & Zimmerman, 2015).

2.10.4.2.3 Level of service

The level of service (LOS) of a system is of great importance in an integrated system, considering how the service capabilities of the system relates to its network capacity. LOS can be enhanced by minimising transfers, minimising overall travel time and making the system more efficient in its operation such that it is more capable of fulfilling the current travel demand (Fang & Zimmerman, 2015).

2.10.4.3 Step 3 – Operational integration

Operational integration provides an integrated network layout through coordination, careful planning and synchronised schedules between all travel modes and routes in a PT system. The use of common fares, a convenient ticketing system and integrating travel service information in this process minimises the interruption of space and time, removes competition between service providers and in turn satisfies passenger expectations (Nielsen, Nelson & Mulley, 2015; Poliak et al., 2017).

2.10.4.3.1 Common ticketing systems

The use of a common ticket fare system establishes a common ground for operators of different PT modes to integrate their services and share revenue (Nielsen, Nelson & Mulley, 2015; Menckhoff, 2005). For example, Singapore uses an integrated ticketing system called the EZ-link smart card, which is cashless and allows commuters to seamlessly travel and pay for different types of trips (Ibrahim, 2003), thus addressing

issues relating to theft and not paying for trips while also enhancing payment convenience (Fang & Zimmerman, 2015). This decision is helpful in the sense that it promotes better modal regulation, provides PT with priority over automobiles and provides commuters with increased convenience as only one ticket needs to be bought (Shaw, 2006; Nielsen, Nelson & Mulley, 2015; Menckhoff, 2005).

2.10.4.3.2 Integrated management

This integration step includes integrating management systems, such that all intelligent transport systems (ITS) of travel modes are streamlined into a single system that serves traffic management on arterial roads and highways (Fang & Zimmerman, 2015).

2.10.5 Ways to promote transport network integration

PT integration in many developing cities remains a challenge due to a lack of synergistic leadership between authorities, all needing to serve a role that enables specific network components to become more synchronised. This type of collaboration should ideally be linked to a source of funding and an authority that can approve of integration plans so that these plans can be put into action (Land Transport Authority, 1996).

The way PT is presented to the public affects the success of the network's operation. Therefore, by improving the attractiveness, sophistication and quality of PT services, more commuters may become attracted by the option of being able to travel with frequent, guaranteed door-to-door travel services (Nielsen, Nelson & Mulley, 2015; Saliara, 2014; Janic & Reggiani, 2001). This could result in commuters becoming more comfortable with concept of modal integration and support its development.

The safety of passengers must be held in high regard in the design and operation of PT modes in order to encourage elevated use of PT services. To address this vital factor, Singapore's transportation authorities created a Safety Assurance Unit with the goal of guarding PT infrastructure and ensuring the use of reliable safety measures in PT service operations. The rise in operation costs must be considered when planning to integrate and evolve systems, as some commuter may not be willing to pay more to shift to and use integrated systems (Ibrahim, 2003).

After harmonising the operation of modes in the network, arrival and departure times of routes and modes can be integrated to optimise the operation of the network, thus reducing travel and waiting times. Communication with passengers is a key consideration in this aspect (Poliak et al., 2014).

2.10.6 Benefits of network integration

Integrating a city's PT network enables commuters to travel in a simpler, swifter and more convenient way between locations with user-friendly PT hubs interchanges, while also being more cost-effective for travellers and providing them with an enjoyable travel experience. Through coordination of various travel modes, integrated systems are more convenient to use than private modes of transportation, significantly reduces road traffic congestion and makes transport business more financially viable by minimising unnecessary trips and transfers (thus reducing overall operating costs) and attracting great numbers of passengers, in turn boosting revenue earned by services (Ibrahim, 2003; Land Transport Authority, 1996).

Among the extensive benefits of an integrated transport system is the development of the system's PT service provision. This serves the enhanced provision of travel information, journey planners and trip booking systems. Travel information provided in an integrated system offers real-time information on mode locations as well as arrival and departure times by means of information display panels (Ibrahim, 2003).

In the case of Singapore's PT revival, bus locations as well as arrival and departure times are tracked using an Integrated Bus Operating System (IBOS), and PT trip journeys can be sequentially planned using electronic travel guides through consideration of the trip cost, minimum travel time and number of transfers required from origin to destination. Passengers can pay for their trips with or without cash thanks to the provision of cashless fare systems, thus making PT more attractive due to enhanced convenience. Similar to mobility-as-a-service (MaaS) modes, taxi booking systems in this city were optimised using GPS networks, which recognises trip requests and assigns passengers with the nearest taxi (Ibrahim, 2003).

2.10.7 Innovation in integration

In early 2002, Singapore (a developing country like South Africa) presented the Enhanced Integrated Fare System, allowing fares to be paid by holding a Smart Card next to a card reader. The fare cost is then deducted from the card, thus enhancing the service's LOS by speeding up the transaction rate (Ibrahim, 2003). Contactless, electronic fare payment using these Smart Cards are being introduced globally to tackle crime and ensure trip fares are paid after using a service, with the difference that trips are paid based on the distance or duration of the trips (as opposed to the number of transfers) and all revenue in the integrated system is split evenly among the number of PT service operators (Fang & Zimmerman, 2015).

A multi-pronged approach was applied in Singapore to optimise the system and make it more affordable, ensuring the system satisfies the network's demand and serves national goals in the economic and environmental agendas. This approach aimed to optimise the city's PT system by integrating land use and

management of PT services as well as vehicle ownership, thus reducing the overall trip counts and minimising road traffic congestion (Land Transport Authority, 1996).

Flexible transport systems (FTS) are becoming increasingly popular as they have overcome more traditional PT provision with fixed route timings, assigning routes and times based on passenger demand instead (Wright, 2013). It is important that innovative solutions aimed at serving a vulnerable, dependent commuter population whose mobility is limited are dependable, integrated with other modes in the network and are well informed by providing good-quality travel information on mode accessibility, various mode options and intermodal transfers, as the needs of this population cannot be served otherwise (Cottril et al., 2020).

Chapter 3 Research Design

3.1 Introduction

Now that the literature applicable to the study's topic has been discussed, this chapter outlines how the study's methodology is designed to meet the research objectives specified. Initially, the research paradigm selected is investigate with a justification for why it was chosen. A budget for each research phase is then presented and an indication of what type of data is desired from either research is discussed. Thereafter, the limitations and delimitations of the study are considered, and different components of the study's research design (studied in literature) are selected. Following this, the study's sampling design and research approach (to be used as a study guide) are developed, ethical considerations are stated and fully considered in the context of the study, and the data collection methodology for either research phase is developed and applied.

3.2 Research paradigm

This section provides a justification for the research paradigm best fitted to this study. Scholarly insights on the chosen **Pragmatist** paradigm are offered to best understand its context so that the study can be best positioned to align with its unique philosophy.

3.2.1 Justifying research paradigm selection

The Pragmatism paradigm is a combination of the Interpretive and Positivist paradigm, implying it accepts and utilises the beliefs and approaches followed by both research paradigms (Mingers & Wilcocks, 2004). Researchers in the *Interpretive* paradigm believe that valid knowledge can only be found through in-depth reflection into the matter being studied, creating personal, subjective insights from their experience and thus embodying a *qualitative* research approach (Rahi, 2017). Alternatively, researchers in a *Positivist* paradigm believe that reliable knowledge is only found using observation and experimentation, usually selecting scientific, empirical methods like surveys and data analysis to generate knowledge – this paradigm thus follows a *quantitative* research approach (Levine, Sober & Wright, 1987).

Research in the field of civil engineering requires scientific methods, data and results and is thus oriented in a *quantitative* research approach suitable to a Positivist paradigm. However, in order to successfully investigate the influence of HCD measures in enhancing the desirability of Gauteng PT service provision, applying only a quantitative approach would limit the validity and usefulness of the results. HCD focuses on making human needs, preferences and capabilities the centre of all decision making, design and infrastructure provision (Mitchell, Claris & Edge, 2016; Fishman et al., 2019; Invitro Innovation, 2014),

meaning a qualitative angle more typical of the Interpretive paradigm is also vital in understanding the South African PT context more completely.

The Pragmatism paradigm allows various perspectives, methods and approaches to be considered in the research process, meaning both insights and facts are created and applied in an effective, complementary way to promote a better understanding the problem statement and address the research questions (Goles & Hirschheim, 2000; Goldkuhl, 2012; Morgan, 2007; Morgan, 2014; Dillon et al., 2000). As such, a Pragmatist philosophy aligns well with the needs of this study, aiming to both understand the topic through the insights gained from expert interviews and apply these insights with a numerical method like quantitative surveys to quantify the perceptions and emotive response of Gauteng PT users. The problem-centred nature of pragmatism also marries well with the elements of HCD models, in which the first phase is understanding, investigating and defining the stakeholders, problems and opportunities (Fishman, 2019; Invitro Innovation, 2014; Dalberg, 2016).

Given that scholars confirm that pragmatism best satisfies the needs of a mixed-methods study (Morgan, 2014; Johnson & Onwuegbuzie, 2004), this paradigm was thus considered the best alternative to utilise the qualitative considerations of HCD to complement the quantitative data and facts resulting from research. The intention is to use both types of research approaches in a mixed approach to find out whether the application of HCD thinking in Gauteng PT design is more favourable to commuters and could enhance their satisfaction with these services.

3.2.2 Application of selected paradigm

Care must be taken to properly understand and define the problem statement in as many iterations necessary, through application of abductive reasoning (Goles & Hirschheim, 2000; Goldkuhl, 2012; Morgan, 2007). This iterative, optimisation process ensures the research problem, research methodology and research design are refined and selected to align with the research objectives, while also addressing real world issues in Gauteng's PT industry.

It will also be important to consider multiple points of view (experiences and perspectives of both the researcher and respondent) and utilise many different methods (interviews, data analysis, etc.) to quantify the influence of the final HCPTD principles on the success and desirability of PT services, also assisting in uncovering helpful facts (Dillon et al., 2000; Morgan, 2014). Notably, empirical inquiry should be done in a reasonable and necessary fashion by clearly defining the purpose and objectives of such inquiry so that the investigation is properly guided (Dillon et al., 2000).

All research questions should also be carefully considered and refined, as the research methodology, research design and method selection are selected based upon how well it answers the research questions

and achieves the research objectives (Tashakkori & Teddlie, 1998; Morgan, 2014). Therefore, care should be taken to reflect on what the research aims to achieve, by carefully defining the research objectives (while considering various perspectives) and ensuring they meet SMART standards. Systematic reflection should be practised in the abduction process to carefully refine the research questions and understand the problem at hand, thus selecting a research design and methodology that will yield reliable results.

Furthermore, both the methodology (quantitative) and epistemology (qualitative) of Gauteng's PT context should be explored to gain an in-depth understanding of the problem (Morgan, 2007). Both approaches can be incorporated by gathering complementary insights and statistic data from multiple research methods such as interviews, surveys, synthesis of personal experiences and investigating scientific, statistical research methods from related studies. Importantly, the sample population and sample size in this study should be well defined and carefully explained. Given that the problem-centred pragmatist approach is already limited by its ability to identify and solve real world problems because it is specific to only a certain context (Thompson, 1996), all results would only be applicable to the specified sample population and context of Gauteng's PT network.

3.3 Budget

3.3.1 Phase 1 – Qualitative interviews

It should be noted that the budget required to fund this phase of research is quite minor. The qualitative interviews conducted in this research phase take place online over Zoom Meetings™ and are recorded on this platform as well, meaning no resources are required to travel to and from interview participants. In addition, all experts participating in the study are doing so according to their own given consent and potential interest in the study, so the researcher is not obligated to paying or incentivising experts for their participation. The interview analysis procedure is also done on software the researcher already owns.

However, the one cost that must be catered for is the airtime used to initially contact and communicate with prospective clients. According to Vodacom (2021), a local call rate of R0.79/minute is billed when calling from a Vodacom account, which the researcher makes use of. Assuming the researcher makes calls that amount to a maximum of three hours during the first research phase, the following can be budgeted for airtime:

Airtime cost = R0.79/minute x (3 hours x 60 min/h) = R142.20

3.3.2 Phase 2 – Quantitative surveys

While Phase 1 did not require much funding to collect data, more funding is required to collect survey data in public during the second research phase, as the researcher needs to travel to data collection sites, buy COVID-19 mitigation items and pay assistants helping to collect data. Please note that all expenses are paid by the researcher with support from his bursar. The purpose and estimated amount of each Phase 2 budget item is summarised in Table 2. Below, research is conducted and explanations are provided to inform how much each budget item is expected to cost.

3.3.3 Calculations of expected data collection duration

According to the data collection scenarios (DCSs) proposed for the Phase 2 data collection (see section 3.10.5.5), a maximum total of 242 in-person survey responses is required for DCS 1 (the most ideal scenario). It is assumed that in-person data collection takes place for a maximum of seven hours a day (9:00 – 16:00) and starts at 9:00, meaning the bulk of travelling would already have been completed. Data is collected during this time period as it is more likely that commuters are in public waiting to use PT services, either to travel to intermediate destinations or home. Furthermore, the researcher is able to collect data during this time period while it is light out.

Based on the findings of the two pilot studies (five surveys each) and the fact that the final survey has been simplified from four- to two pages, it can be assumed that a survey response should take a participant no

more than **six minutes** to complete. However, given that the study's information must be presented to the prospective participant, pictures must be taken of the survey response afterwards, and surveys and pens must be sanitised after a response, it can be assumed that it will take approximately **ten minutes** to collect one survey response.

Furthermore, it will take time to travel between data collection sites (if needed), walk around to seek potential participants and rest – approximately 1.5 hours of the day are assigned for this purpose. Thus, the following calculations are done to determine the maximum expected duration for data collection:

- Maximum time available to collect data (*hours*) = 7 − 1.5 = **5.5 hours**
- Number of surveys completed in a day = (5.5 x 60) minutes / 10 minutes = **33 surveys per day**
- Maximum duration of data collection = 242 surveys / 33 surveys per day = **7.33 days**

Thus, a maximum total of **seven days** is required to collect the in-person survey responses for DCS 1, namely 242 responses. However, this depends on how swiftly the required survey responses can be collected and the capabilities of the researcher and data collection assistant (DCA). This amounts to data being collected a total of **38.5 hours maximum** during in-person data collection.

Based on the capabilities of the research team, it should be noted that it may not be possible to fulfil the first DCS. Thus, discretion is given to then progress to the second or third DCS (decreasing in idealness), based on current circumstances in public and the current capabilities of the research team at the time. However, it would be ideal to achieve DCS 1, as the most resources are being devoted to the in-person data collection, among other reasons.

3.3.4 Sources, description and calculation per item

Data collection assistant (DCA):

Assuming help is being provided over a maximum period of ten days, it seems reasonable to pay the DCA R40/hour for his efforts, including translation, protection and administrative field work like sanitising the laminated survey sheets and whiteboard markers. Assuming a maximum of 38.5 hours of data collection, a maximum total of **R1540** can be budgeted to pay the assistant.

Uber™/Bolt™ trips to data collection sites:

Since the DCA does not have a car, it is assumed that MaaS such as Uber™ and Bolt™ are used to travel to data collection sites far from the researcher's home. Assuming the research team will need to travel eight days out of the maximum total of ten days at an average estimate of R60 per one-way trip, the following can be budgeted for MaaS trips:

MaaS budget = R60 x 2 (return trip included) x 8 = **R960**

Gift incentive:

A gift such as a clothing item, an electronic accessory, or a sealed snack or sweet will be given to each in-person respondent to thank them for the time and effort taken to participate in the study. The gifts bought will depend on what items the researcher finds to be affordable and desirable to participants. For a maximum of 242 survey responses and an estimate of R10 per gift, a maximum total of **R2420** be budgeted for gift incentives. Notably, this is quite a large cost for only gift incentives and may affect which DCS is selected.

COVID-19 mitigation

In order to mitigate the risk of virus transmission during the in-person survey, cloth face masks, rubber gloves and sanitiser disinfectant must be purchased. This ensures no airborne or physical contact is made while in public and that laminated survey sheets are disinfected after every survey response. While the researcher and DCA own masks, participants who do not own a mask will be given one to mitigate the risk of virus transmission.

According to Dis-Chem (2021):

- a pack of 20 cloth face masks costs R120
- a 500ml bottle of hand sanitiser costs R42
- a box of 200 tissues to apply the hand sanitiser costs R18
- a set of yellow rubber gloves cost R13 each. Since both the researcher and DCA are going to use a pair, a total of R26 is required.

Thus, a total of **R206** is required to mitigate all virus-related risks.

Laminating survey sheets

A maximum number of five surveys will be printed, amounting to two pages each (back-to-back). Thus, a maximum number of five pages will be laminated for in-person data collection. PostNet (2021) charged R35 for an A4 colour page, printed on both sides and laminated. Thus, a total of **R175** was charged for all printing all five surveys.

Online gift incentive

As a means of encouraging online participants to complete a survey response, a **R500** gift incentive is suggested. This will be sufficient for the number of responses required in the digital data collection to encourage enough people to complete survey responses.

3.3.5 Table summarising budget

Table 2 below summarises the purpose and estimated funds required per budget item. As such, the researcher should budget a total maximum amount of **R5801** for the second phase of data collection.

Table 2: Budget for Phase 2

Budget item	Purpose	Estimated funds required
Data collection assistant (DCA)	Protect researcher and possessions Translator, if needed Assist the researcher to collect data more swiftly from potential respondents	R1540
Uber™/Bolt™ trips to data collection sites	Driving to PT hubs such as taxi ranks, train stations and bus stops around Johannesburg to collect specific data	R960
Gift incentive	Thank people for participating in the sample	R2420
COVID-19 mitigation	Mitigate all risks relating to the COVID-19 virus Protect the health of all in-person stakeholders	R206
Laminating survey sheets	Allows participants to fill out survey responses at a distance from the researcher for enhance the overall health and safety of all research stakeholders	R175
Online gift incentive	To encourage online participants to complete a survey response	R500
TOTAL		*R5801*

3.4 Desired information per research phase

This section elaborates on the type of data the researcher intends to collect in each phase of the study to answer the research questions and achieve both the research objectives and research aim. Providing a description of the data required would inform which research methods would be the most effective in gathering the desired information.

3.4.1 Phase 1 – Qualitative data

In the first phase of data collection, the researcher intends to collect *qualitative*, *narrative* data to study the strategies employed by South African transport authorities and assess how customer needs, preferences and complaints are accounted for in the design of PT services. In addition, a greater understanding of how HCD is being applied in South Africa and which human-centric approaches work most effectively in South Africa's unique circumstances are desired. This would clarify which principles of HCD are currently being applied to South African PT design, how customers respond to these measures and what customers need or expect from PT services to be satisfied.

Furthermore, narrative data is required to determine which aspects of Gauteng's PT design need improvement or optimisation and which principles of HCD and PT design would be most applicable to Gauteng in improving the quality of PT and enhance customer satisfaction. Narrative data from experts in either field would also shine a light on which considerations and insights must be incorporated into the design of the second research phase or investigated therein. Qualitative data such as this can be collected by conducting interviews with both HCD- and PT professionals employed in the Gauteng Province, where an equal number of interviews should be conducted with HCD- and PT professionals to gain rich, deeper insight into HCD thinking and how this can be successfully applied to Gauteng's PT paradigm.

3.4.2 Phase 2 – Quantitative data

Based on the insights drawn from Phase 1, the researcher intends to collect *quantitative, numerical* data from Gauteng commuters in Phase 2 to reinforce the initial qualitative interview findings. This phase should test the applicability of the initial qualitative findings that are encapsulated into the list of initial HCD- and PT principles and obtain data that supports these findings, by assessing whether a lack of HCD measures is the cause for any dissatisfaction they may have with their services.

This phase should aim to correlate the relationship between the unmet needs of PT users and a lack of HCD elements in PT service design, so that the researcher can assess whether HCD elements could address current PT issues and satisfy commuter needs. The quantitative data collected should encapsulate commuter perceptions of their PT services as well as their travel preferences to quantify whether a relationship exists between lack of HCD measures in transportation and the satisfaction of PT customers,

thus informing the study's hypothesis. Quantitative data describing commuter needs, preferences and perceptions should be collected to provide a reliable basis for South African transport authorities to constructively reform PT design by placing customer needs and preferences at the centre of decision making.

Using the qualitative interview data from Phase 1, a list of initial HCD- and PT principles were developed with support from literature. This phase of data collection aims to narrow down the initial list of principles into 3-5 principles for either study construct (HCD or PT design) which are most relevant to Gauteng PT users in their travels and of highest priority to Gauteng's current PT development. Survey questions were designed to test the applicability of each principle with commuters in the field to confirm which of these principles are most applicable to the current status of Gauteng's PT design.

3.5 Research limitations and delimitations

This section considers the study's limitations and delimitations, indicating which aspects fall outside the study's scope and couldn't be controlled by the researcher, or which aspects were deliberately *not* considered either because they were too complicated or unethical to address (Cronje, 2013; Price & Murnan, 2004). These considerations directly affect the internal and external validity of the study's results, meaning their discussion and influence on the study is imperative.

3.5.1 Definitions

A research *limitation* is a bias imposed by a researcher on parts of the study which cannot be controlled or were not controlled, as they would affect the reliability of the results. A research *delimitation* is a limitation deliberately introduced into the research design in order to make the results representative of a specific population (Price & Murnan, 2004). As such, research delimitations are controlled by researchers in order to taper the scope of a study and thus simplify the achievement of the study's goals and objectives. These explain why the research was *not* conducted in a certain fashion and why specific aspects were omitted from the study (Theofanidis & Fountouki, 2019).

3.5.2 Internal and external validity of results

According to Fink (2003), research limitations can stand as threats to a study's internal validity or external validity. A study having *internal* validity contains precise study outcomes with no bias, thus precisely estimating what must be measured (Fink, 2003). A study's internal validity is threatened by occurrences such as false, socially acceptable survey responses, language barriers or probing responses about the same study theme, carrying the risk of collecting responses that don't truly reflect a person's views about the study topic (Fink, 2003; Price & Murnan, 2004). The results of a study with *external* validity correctly represents the selected sample population, meaning these results can be generalised to represent the

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whole sample population (Fink, 2003). A study's external validity is threatened by a lack of proper sampling, the collection of insufficient surveys in the research field and non-randomly assigning subjects to data collection groups (Price et al., 2004).

The research limitations and delimitations must therefore be included in the study in order to improve the internal and external validity of the study's outcomes. The different types of research limitations and delimitations considered in this study are discussed in the subsequent sections.

3.5.3 Research limitations

3.5.3.1 *COVID-19 regulations*

In order to understand how the COVID-19 pandemic affects the data collection process in this study, it is necessary to become familiar with these regulations and understand which directly affect data collection. This section summarises the regulations that affect the data collection process as well as the limitations they pose on the study. Note that these regulations only apply to respondents recruited *in-person*, in public; pandemic regulations would not affect those contacted digitally to participate in the study.

3.5.3.1.1 Summary of regulations

It is important to note that, as the pandemic situation evolves, some of the regulations may change. Therefore, only the most basic considerations affecting the data collection process in the pandemic were noted, as these would not change too drastically when the regulations are altered. In order to prevent transmission of the COVID-19 virus, the researcher intends to, at most, only promote the research being conducted and recruit sample participants in public under strict adherence to the regulations of interest to the data collection process. As such, absolutely no direct or indirect physical contact was made with candidates and data was only collected digitally once willing persons showed interest in the study.

Initially when the COVID-19 lockdown began, President Cyril Ramaphosa suggested a levelled alert approach to respond to the evolving pandemic situation. The nation began on alert level 5 (the highest level) on 16 March 2020, while the levels are incrementally reduced over time to a minimum of level 1 (lowest alert level), based on how well transmission is contained and the need for greater awareness to protect the health of South Africa's citizens (South Africa Department of Health, 2021).

On 11 January 2021, the President declared that an adjusted level 3 lockdown would be maintained. The regulations directly affecting the data collection process are as follows (South African Government, 2021a, b):

1. *No-one may provide any form of service on any PT mode*, implying the researcher may not collect data from commuters on any PT mode.

2. *Social distancing of at least 1.5 m must be held between people*. Thus, if the researcher intends to promote the research being done to employ sample participants, a distance of 1.5 m must be maintain between any potential respondent.

3. *A cloth face mask must be worn when in a public area.* In conjunction with regulation 2, a face mask must also be worn when approaching potential candidate. Importantly and conversely, the researcher should refrain from approaching any person without a face mask or seeming ill, as this could affect the health and well-being of the researcher as well.

4. *No social gatherings (50 persons or more (indoor) or 100 person or more (outdoor) are allowed.* The researcher must thus aim to minimise the number of respondents approached at one time to ensure no risk is imposed to any of the persons involved, while also adhering to the other regulations of interest. Therefore, any personal approach must be done discretely and completed as soon as possible to avoid unnecessary attention being attracted to the researcher.

5. *The closing time for most recreational establishments, such as gyms, restaurants or sporting facilities is 20:00, while a curfew exists between 21:00 and 05:00.* This consideration affects the time in which potential candidates can be approached and employed, as well as the type of PT user that forms part of the study. However, it is unlikely that people would be approached in the evening or at night to preserve the safety of the researcher.

6. *Certain areas in South Africa have been denoted hotspots for the transmission of COVID-19*, suggesting the need for stricter adherence to the regulations. Seeing as the researcher is located in the City of Johannesburg during data collection, a more careful approach must be practised to adhere to the above regulations of interest.

3.5.3.1.2 Effect on Phase 1 – Qualitative interviews

The transport professionals selected cannot be interviewed in person due to COVID-19 regulations. Therefore, professionals selected to participate in the Phase 1 of the study were interviewed in a Zoom™ meeting that doesn't require personal contact. This meeting was recorded and then transcribed and coded after the interview. According to the views of Albertyn (2020), interviewing respondents in the comfort of their own home or office may be beneficial to the accuracy and validity of the study's results, as people feel more relaxed and at ease there. As a result, professionals being interviewed may provide more reliable, detailed and innovative insights on the study's aspects, which could shed light on a factor not yet conceived by the researcher and provide clearer, more useful responses. In turn, the information collected would reinforce the understanding of South African commuters as well as the considerations in the second phase of research, thus preparing the researcher better for designing an apt survey and collecting data.

3.5.3.1.3 Effect on Phase 2 – Quantitative interviews

COVID-19 regulations affect data collection in Phase 2 the most, as it limits the amount of people that can be contacted physically and careful regulations must be followed throughout the process. Thus, laminated survey sheets, whiteboard markers and hands must be sanitised regularly to prevent virus transmission, while the researcher and DCA must wear masks and maintain social distancing. The pandemic may also affect participant's willingness to participate in the study as they may be cautious of contracting the virus, so the data collection team must find a gentle, authentic yet effective way to engage with Gauteng PT users during pandemic conditions. Each participant also needs to fill in the COVID-19 contact register, affecting the swiftness of data collection and participant's willingness to participate voluntarily.

3.5.3.2 *Sample size*

The sample size for the second phase of research was determined in section 3.7.3.2 of the study. The number resulting from this calculation determines the minimum number of respondents required to participate in the sample in order for the research aims to be fulfilled (SurveyMonkey, 2021a). However, the researcher can only include those with whom direct contact can be made as well as those who are willing to offer their time to complete the survey, meaning there is a likelihood that an insufficient number of responses may be collected. In addition, respondents recruited in person (while adhering to COVID-19 regulations) may find it tedious to have to complete the survey, COVID-19 contact register *and* the informed consent form, so it's likely prospective participants may decline the invitation to participate.

A lack of responses to make us the calculated sample size directly affects the study's external validity (Price et al., 2004), so a number of participants as close to this sample size must be recruited. In order to maximise the number of survey responses and optimise the study's external validity, the entire process from when potential respondents are contacted to when data is collected must remain simple, authentic, understandable and engaging to encourage each potential respondent to commit to completing a survey. A sufficient number of responses can only result with the willing support of Gauteng PT users, so exercising measures such as apt incentives, authentic interactions and short, clear sharing of information is key.

3.5.3.3 *Time*

The researcher is limited to approximately two years to complete all parts of a relatively complex mixed-methods study, involving two sequential research phases in which the collection and analysis of data must commence. Ethical clearance for each research phase had to be requested and accepted separately, after which data collection and analysis had to be conducted sequentially – this could take quite some time, so limited time may be available to complete the study before 1 November 2021.

3.5.3.4 *Finances and travel*

The researcher is provided with a bi-annual bursary allowance covering all educational aspects of his studies such as tuition, accommodation, travel, food and other vital needs. The researcher has not yet acquired a driver's license, meaning travel arrangements are limited to the use of MaaS trips or using PT. While these funds are sufficient to provide for the above-mentioned needs, the researcher is limited to a specific number and distance of MaaS and PT trips to collect data as well as finances to purchase all data collection necessities such as incentives, COVID-19 accessories and printing costs. Thus, the funds available may limit the capabilities of the Phase 2 data collection.

3.5.3.5 *In-person data collection sites*

The researcher is situated in the Gauteng Province (GP) during the data collection phase of the study and has limited finances; travel is also limited and complicated by COVID-19 regulations. Due to these limitations, in-person survey data can only be collected from commuters in the Johannesburg area where it is convenient and possible to travel to. Because the researcher has not yet acquired a driver's license, transport arrangements are limited to MaaS and PT (which the researcher is not familiar with, as these are the most affordable.

3.5.3.6 *Lack of access to technology*

It is likely that a portion of the study's captive PT sample may not have access to technology such as smartphones or laptops to complete the online survey or know how to complete a survey online. Thus, it may be difficult to obtain online survey responses from participants in the sample population and limit the number of online survey responses. As such, the greater portion of survey responses must be collected in person, placing additional pressure on the data collection team. These less fortunate PT users must be included in the sample as they hold very relevant, reliable views that would be helpful in the context of this study.

3.5.3.7 *Language and understandability*

A portion of the study sample may consist of lower-income commuters whose level of education is limited and may not understand English. Thus, it may be difficult to communicate the key study information to them in a way they understand, or some may not be able to understand or read they survey. This may limit the number of people willing or able to participate.

To overcome this possibility, survey questions will have to be stated clearly, simply and understandably; symbols and emoticons can be used to communicate particular aspects. The researcher should also consider translating study introduction and surveys into the native Gauteng languages, but the DCA has the capability of expressing the study information in other languages that participants better related to.

3.5.3.8 *Access to respondents*

Since the COVID-19 regulations limit the researcher's exposure to potential sample respondents, the sample is limited to all people that can be contacted over social media, communication platforms and in public (while adhering to strict social distancing regulations), as well as those willing to participate during chaotic pandemic circumstances. While participants may be accessed through these means, the researcher and DCA may still struggle to collect enough data from each commuter type as required in the research design. The researcher's access to potential respondents is quite limited during pandemic circumstances and due to financial limitations, and permissions may be needed to collect data at specific sites during COVID-19.

3.5.3.9 *Building trust with respondents*

It is one thing locating potential respondents and collecting responses; it is another thing ensuring the reliability and accuracy of the information provided. Since people are required to be at least 1.5 m from one another at any time, wearing face masks and likely harbour fear of getting infected by the virus, it may be a challenge to overcome the mental and emotional boundaries of some respondents, connect personally with them and build trust. A lack of trust in or respect for the researcher may influence the accuracy and reliability of the data provided due to the participants' perspectives. Therefore, the researcher would have to carefully consider how the accuracy and completeness of data can be ensured and optimised during personal interactions with potential respondents and may also need to consider the possibility of a lack of survey information or dishonest responses during data collection.

3.5.3.10 *Ensuring accuracy and completion of information*

The researcher aims to incentivise respondents for their participation in the study by giving each survey respondent a closed sweet or snack. However, some participants may not be interested in the context of the study and some may just participate for to get an incentive, providing incomplete, poorly considered responses just to finish quicker. Participants may omit questions or misunderstand questions due to a possible educational or language gap and give poorly considered answers. Thus, the researcher and DCA must check survey responses before taking pictures of them to see if a participant had missed or misunderstood a survey question to ensure the reliability and validity of the survey data.

3.5.4 Research delimitations

3.5.4.1 *Sample population*

The study's sample population includes adult GP PT users who have made used of PT services since 2018. Since the researcher is living in the GP during the study, only commuters in Gauteng can be recruited in Phase 2. Therefore, to ensure the same local context is served through this research, only experts and commuters situated in the GP are permitted to participate in this study.

To ensure the study incorporates the views and insights of all South African PT users, while ensuring these commuters are ethically allowed to provide data and knowledgeable enough to provide reliable views, respondent ages are selected as <u>18 years and above</u>. Thus, no minors are allowed to participate in the study. Note that no upper age bound is indicated, allowing the views and insights of all adult Gauteng PT users to be utilised in the study, so long as these views are applicable to recent events and thus not outdated.

3.5.4.2 *Scope of South African transportation*

The following aspects of Gauteng PT are excluded from the scope of the study to ensure all information acquired is factual, reliable and consistent:

- **Politics** – no politically motivated information
- **Misinformation** - conspiracy theories, rumours and any form of non-factual information
- **No operators or promoters of PT services** – they aren't commuters and their views may be biased

Thus, the main focus of the study is to investigate aspects such as the design, leadership and integration of Gauteng's PT, understanding the views, emotive responses and current involvement of *commuters* in the PT system.

3.6 Selections to guide research design

The selection of a study's research design is influenced by the selection of a research paradigm, the research questions, the context of the study and its feasibility, while the available time to complete the study and the researcher's qualifications/experience also play key roles. A study's research design encompasses both data collection and data analysis, thus describing the methods, instruments and target population chosen to gather for the desired data (Albertyn, 2020). Therefore, this section selects of the key aspects of this study's research design: the MM research strategy, timing, weighting, mixed and theorising, as proposed by Creswell (2009) and Mertens (2003).

3.6.1 Mixed methods research strategy

After considering the characteristics of each MM strategy and the researcher's quantitative experience in academia, a decision was made to use a sequential *exploratory* strategy (SES) to the guide the research. This strategy better embraces the element of uncertainty in the research, meaning liberty is available to first explore the field and build upon the knowledge gained without deciding on anything upfront. In addition, a SES would improve the favourability of advisors or academic committees more familiar with quantitative approaches toward more qualitative-based research (Creswell, 2009). SES are employed mainly to study a specific phenomenon by testing fundamental aspects of a theory and creating research instruments, while the qualitative results are also applied more generally to an array of population samples based on the original study sample (Terrell, 2012).

Qualitative data is gathered and processed in Phase 1, followed by collecting and analysing quantitative data in Phase 2 to reinforce and interpolate these initial findings. Therefore, numerical data is used to interpret narrative findings (Creswell, 2009). Thereafter, interpretation of the qualitative and quantitative findings takes place to discuss what the implications of Phase 2's findings are to the study (Terrell, 2012; Creswell, 2009), given that narrative data tested the initial qualitative insights. Important choices must however be made on which aspects of the qualitative findings are studied further in the following quantitative research, as the choice of themes or topics greatly influence the contribution of the research (Creswell, 2009).

While the phased approach of SES design can be implemented easily, collecting both quantitative and qualitative data tends to be time-consuming when both phases are assigned the same priority, especially if the researcher must return to the field twice and also needs to analyse and mix the complementary data and findings. However, thanks to its basic phased approach, the SES procedure can be expressed in reporting far simpler than concurrent approaches where both phases are undertaken simultaneously (Creswell, 2009; Terrell, 2012).

3.6.2 Timing

Given that a SES was selected, this study followed *sequential* timing, as termed by Creswell (2009). As a result, quantitative and qualitative data was gathered in two distinct phases, where one data type informs, supports and elaborates upon the other. Seeing as the researcher is trained and experienced in the field of civil engineering, two insights should be considered:

1. The researcher is more experienced and familiar with quantitative methods, data collection and data analysis, and is new to qualitative approaches. Thus, sufficient time must be made to research, present and apply qualitative data collection and data analysis methods in Phase 1.
2. External examiners and supervisors considering the research in this study mainly expect that results and findings are grounded in quantitative methods, data and analysis, given that engineering is mainly a quantitative field.

Therefore, a major portion of this study should be **quantitative** to satisfy the insights above. The basic MM report structure recommended by Mertens (2003) was adapted to be applied in this study as follows:

1. gathering, analysing and interpreting qualitative data in Phase 1
2. conducting quantitative research in Phase 2 to support and strengthen the qualitative findings
3. presenting a discussion and conclusion, mentioning how the quantitative findings complemented and reinforced the initial qualitative results, as well as how this combination of approaches assisted in answering the research questions and resolving the research problem

3.6.3 Weighting

This aspect determines to what extent one data type is used over the other. Its selection is based upon 1) the purpose/goal of the research, 2) the intent of the researcher and 3) the academic audience of the study (Creswell, 2009). All three aspects were discussed, and their respective weighting considered before an overall weighting decision was made.

The research aim is to offer a three to five HCPTD principles tailor-fitted to Gauteng's context by making commuter needs the centre of transport decision making. This aspect leans more towards a *qualitative* weighting, as HCD, customer satisfaction and commuter preferences are all highly subjective and based on personal perceptions. Due to the primarily quantitative background and experience of the researcher, this aspect can be considered to have a more *quantitative* leaning. Lastly, the audience for this research are mostly professionals in the civil engineering discipline, having a more *quantitative* leaning.

Therefore, considering all three aspects, the weighting of the study was chosen to be more **quantitative**.

3.6.4 Mixing

Data sets in a SES are only compared and mixed in the interpretation section of the study, that is after both research phases are completed to interpret how the findings of Phase 2 support and contextualise the findings of Phase 1 (Terrell, 2012; Creswell, 2009). A MM researcher can employ one of three forms of mixing, one of which is an embedded approach; Creswell (2009) advises this approach is used if time to collect data is limited. This MM study is both complex and requires ample time to collect and analyse both numerical and narrative data, so a decision for an **embedded** data mixing approach was made. Herein, the quantitative data collected and analysed in the second phase of the research plays a secondary role in supporting the qualitative findings of the first phase.

Data sets are mixed in the discussion section of the study, also discussing the implications of these findings on the research questions, research objectives and topic of interest. Thus, separate data sets are not mixed or integrated in any way, but merely used to enhance and support one another's findings. This would greatly simplify data mixing, allowing for complementary data comparisons and helpful, reliable results (Terrell, 2012; Creswell, 2009).

3.6.5 Theorising

As discussed in section 3.2, the **Pragmatism** research paradigm was selected as the philosophy that resonates most with the researcher and the context of the study. The beliefs and implications of this paradigm were thus used as a guideline to select the most appropriate research methods and construct the research design.

3.7 Sampling design

3.7.1 Selecting sampling techniques

This section focusses on selecting the most fitting sampling technique for each research phase and providing an explanation for its selection. Each sampling technique should align with the research design chosen for this study and collect data from respondents that would best fulfil the study's objectives and ultimately achieve its aim.

3.7.1.1 *Phase 1 – Qualitative research*

Given the subjective nature of this research phase, a non-probability sampling technique would be the most appropriate way to gather its data (Elliott, 2020). While this implies that data can be collected faster, cheaper and more simply than a probability sampling approach (Battaglia, 2008), a selection bias may result from the subjective means of selecting the sample (Battaglia, 2008; Hair et al., 2007). Therefore, the variables involved in the study should be clearly defined and sample participants should be selected based on how accurately they can provide information on the relationship between the variables to mitigate possible selection bias. The population of interest, quantity of data required, and the variables being investigated in the research should be carefully defined and considered to ensure the most apt sample is chosen to collect reliable data from (Battaglia, 2008; Hair et al., 2007).

The goal of this phase is to interview HCD and PT design principles in Gauteng to gain deeper insight into the current focus of Gauteng service provision and whether the inclusion of HCD measures in Gauteng PT design would satisfy customers and improve the desirability and quality of these services. Other considerations and insights could also emerged that would serve this intention. Therefore, it is most fitting that an **expert sampling** technique is employed in conjunction with a **snowball** sampling technique in the first phase of this study.

Expert insights and advice would be helpful in guiding the study's approach and better understand the topic before designing and implementing Phase 2 of the study. Also, given the exploratory nature of this research and the fact that it is a relatively unexplored topic, advice from professionals in a qualitative interview would shed light on considerations that were not yet considered and allow the researcher to more comprehensively understand the research topic, meaning the design of the second research phase would be better informed and more applicable. The simultaneous use of **snowball sampling** approach would simplify the process of selecting experts, as those interviewed can be asked to refer other professionals that satisfy the required sampling criteria and required expertise. In addition, a snowball sampling approach would also significantly reduce the risk of a selection bias as the researcher has not made a personal choice to select one candidate over the other (Etikan & Bala, 2017; Hair et al., 2007).

3.7.1.2 *Phase 2 – Quantitative research*

Usually, a probability sampling technique would be more suitable for quantitative research (Creswell, 2009). However, after considering the properties of the random sampling methods available, none resonate with the objective for the second phase of research. Consequently, a decision was made to choose non-probability sampling techniques instead. While this approach has a more qualitative leaning, this phase of research aims to quantify the opinions and subjective preferences of Gauteng commuters, implying the use of a non-probability sampling technique is justified. The sample in Phase 2 can include any Gauteng citizens who have used PT since 2018.

The researcher requires information from those who are well informed about Gauteng PT service and have experiences and views to share. Therefore, a **purposive sampling** technique was employed in Phase 2 of this study. Hence, the researcher should firstly define a sampling objective and be clear about what type of information is required from the sample, followed by using personal judgement to select people in Gauteng who have experienced PT services, have opinions to share and are both available and willing to participate in the study (Etikan, Musa & Alkassim, 2016; Creswell & Clark, 2017; Etikan & Bala, 2017; Bernard, 2002; Creswell, 2009; Hair et al., 2007; Spradley, 1979).

Additionally, when considering the sample size limitations discussed in section 3.5.3, it is likely that the researcher may struggle to locate and employ the exact number of participants as well as the demographic split required due to the COVID-19 regulations. As a result, a **convenience sampling** technique is also selected for the quantitative research phase, implying the people that can be included in the sample comprise of those the researcher can actually access and contact within the digital platforms available, and the degree of personal interactions allowed.

The implications of these sampling technique choices are that the sample can be compiled in an affordable and convenient way (Hair et al., 2007), and that the size of the sample is dependent on when data saturation (or full, comprehensive understanding of the topic) is achieved (Miles & Huberman, 1994; Suen, Hwang & Lee, 2014). This aligns well with the exploratory nature of this MM study, allowing the researcher to select a sample that can provide reliable information to achieve the research objectives and answer the research questions.

Another important consideration of choosing two non-random techniques is the selection bias that could be associated with choosing participants from one's subjective point of view. In the context of this phase in the study, the intention is to distribute quantitative surveys to Gauteng citizens (digitally or in-person) who have used PT since 2018, as the data obtained here was utilised to determine whether HCD aspects in PT services would be palatable for PT users. Therefore, the impact of a selection bias on the reliability of

the study's results is only relevant if those chosen have never used PT and have no opinions thereof; it wouldn't matter who is chosen, so long as they have used PT in Gauteng before.

To mitigate the impact of a selection bias, the researcher merely needs to ensure that the members of the sample have used PT in the past and are both available and willing to share their personal views on the matter, simply by asking the person prior to handing them a survey. In addition, it is more likely the researcher's judgement of the correct sample would be accurate if data is collected at PT infrastructure sites such as train stations, taxi ranks and bus stops, as most people found here would have used PT services recently. However, if data is collected at non-transport related sites such as malls and sidewalk shops to gain more perspectives on the survey topic, the person must first be asked whether they have PT before and whether they would be interested in participating in the study.

3.7.1.3 *Selecting a mixed method sampling strategy*

It is helpful to place the sampling methods selected in the context of the study's MM research design to explain how these methods are related during the research design and data collection. Consider the five MM sampling strategies offered by Teddlie and Yu (2007) in section 2.5.1. Seeing as the two sampling techniques chosen do not operate in more than two distinct phases, nor were they used simultaneously or combined, multilevel or concurrent sampling approaches do not apply. Rather, the first phase gathers more information from experts to better inform the design and sample selection of the second phase (Teddlie & Yu, 2007). Therefore, a combination of a **basic and sequential MM sampling approach** is taken (Teddlie & Yu, 2007) given that qualitative and quantitative sampling are combined simply in two separate phases, while the information gathered in the first phase does to some degree inform the second phase's design and strategy.

3.7.2 Sample inclusion and exclusion criteria

A general introduction into the importance of sample inclusion and exclusion criteria is provided to create an understanding of the role it plays in research. These terms are then defined, and guidance is provided on the considerations involved when selecting effective criteria, after which these criteria are selected, defined and justified for each phase of research.

3.7.2.1 *Introduction*

The most important part of academic research is ensuring the sample population possesses specific characteristics so that the purpose of the study can be achieved. It is for this reason that it is necessary to define sample inclusion and exclusion criteria, to ensure the sample contains respondents with these desired characteristics (Yale, 2020). By comprehensively yet precisely defining these criteria, a group of individuals can be selected that would offer the most accurate useful information to the study of interest,

directly affecting whether the study is feasible or not. Furthermore, these criteria are of great importance during the research approval process, the comprehensiveness of which influences the reliability and integrity of the study's results (Hornberger & Rangu, 2020). Examples of these criteria include variables such as age, gender, personal/work experience or a specific personal trait (Yale, 2020).

3.7.2.2 Definitions

Inclusion criteria (IC) are attributes that a potential respondent must possess in order to be considered as a part of the sample, with the main purpose of omitting unnecessary variables from the sample (Yale, 2020). Conversely, exclusion criteria (EC) are attributes prohibiting a potential respondent from forming part of the sample, consisting of characteristics within as well as outside the person that contradict or restrict the study's goals from being achieved (Yale, 2020; Hornberger & Rangu, 2020). Note that a group of people or type of person can only be omitted from the sample if the researcher provides adequate justification for why it is necessary, by referring to the risk or advantage of the selection with respect to the study's purpose. Evaluation of these choices must be made to ensure no people or groups have been omitted from the study without reason (Yale, 2020).

3.7.2.3 Guidelines for criteria selection and definition

Ultimately, the researcher decides which criteria are the most necessary to include such that the study generates reliable, high-quality outcomes. The research purpose should be used as the main reference to ensure the most appropriate criteria are selected, but also by making clear sense of the purpose of each criterion, understanding how they impact the study's feasibility and familiarising oneself with studies that have similar goals to the research being conducted. Since a study's results must be replicable in order for it to be considered valid, the selection of criteria must be rigorously justified when chosen (Hornberger & Rangu, 2020).

A person is only permitted to form part of the sample if all these criteria are met, thus ensuring the most reliable information is attained for further use in the study. Ultimately, the selection of a candidate depends on whether the person can provide reliable, valid and accurate insights on the topic of interest and whether they are competent or qualified enough to do so to ensure the study yields dependable results. Otherwise, the information provided may produce results that lack integrity and reliability, thus not representing the actual target population to a satisfactory degree (Godambe, 1982). Criteria must be defined carefully enough to guarantee other scholars can replicate the original study's results, carrying the advantage of extensively confirming these results, improving its reliability and causing the study to be considered valid in the eye of the associated research community (Hornberger & Rangu, 2020).

3.7.2.4 *Selecting, defining and justifying criteria*

The IC and EC for each research phase are selected, defined and justified in this subsection, based on the guidelines provided above.

3.7.2.4.1 Phase 1 – Qualitative interviews

3.7.2.4.1.1 Inclusion criteria

It should be noted that, in order to collect information on both PT design *and* HCD elements, two types of experts need to be interviewed: PT experts *and* HCD experts, each of which forms half of the sample. As a result, two unique sets of IC are required for the semi-structured, expert qualitative interviews, indicated as follows:

For the *PT professionals:*

IC1: The candidate must be a qualified engineer with preferably five years' working experience in the field of Transportation Engineering. This ensures correct interpretations of PT design are provided and that the person is knowledgeable on meeting the needs of PT users. An individual with this level of working experience is more likely to provide reliable guidance and helpful recommendations on this study's topic and the research being conducted, as they have practical experience with PT services and whether HCD elements aligns with the country's transport priorities. Such working experience also ensures candidates are very well informed on the current status of Gauteng's PT system to point out which HCD principles are already being used and advise what research, improvements or considerations are most necessary to optimise PT design and enhance customer satisfaction.

IC2: The candidate must possess a strategic position in the municipality or transport department where the interviews are being held, ensuring they are familiar with the transport strategies applied by the municipality, the management of their area's PT system and how customer needs, preferences and complaints are accounted for in their PT services. Leaders in this position would also be actively involved in developing and implementing new PT strategies, so they would be able to offer rich, accurate and helpful insights on the matter.

IC3: Candidates should be knowledgeable about the basic, prioritised travel needs of PT commuters and be able to offer reliable insights regarding the type of PT design and improvements of the current PT system that would serve these needs the best. This in turn ensures the most effective, useful insights are highlighted from the knowledge of the candidates, equipping the researcher with the understanding and information required to establish successful HCPTD principles.

IC4: Those included in the sample must be working in a Gauteng transport municipality project. According to South Africa's Constitution, both national and provincial transportation projects should operate

synonymously between different levels of government, while local municipalities have the authority to manage their own PT networks in accordance with national plans (South Africa, 1996). Then, national policies stipulate that the opportunity to develop local commuter PT services should be competitively tendered to local firms (Department of Transport, 2009).

Therefore, any transportation engineer involved in a local municipal tender to develop a segment of the local transport infrastructure is working in parallel with national transport plans and is thus familiar with current PT development strategies. This knowledge would be very useful in understanding which alterations are of highest priority in Gauteng's PT system and how the proposed HCPTD principles could assist in materialising these objectives.

For the *HCD professionals:*

IC5: Candidates must have at least three year's working experience in the field of HCD and can be working in any occupation aligning with this expertise. With that amount of career experience, these individuals would have the experience necessary to precisely explain which aspects of HCD are effective in meeting the needs of South Africans and advise how these elements can be integrated successfully and effectively into South African PT service design.

IC7: Candidates must possess a qualification in a design thinking, HCD, digital transformation training or any related academic course in which the objective is to develop an innovative product or service both promoted by and based on human needs (Abelli, 2019). This qualification ensures the individual is trained in the field of HCD and innovative thinking, thus having the expertise necessary to provide reliable insights and innovation that would complement the study's goals as well as provide new, previously unconsidered insights.

3.7.2.4.1.2 Exclusion criteria

The EC for the semi-structured, expert qualitative interviews are as follows, applicable to both the PT and HCD experts:

EC1: Candidates may not work in any other country besides South Africa and should ideally be located in GP or have experience working there. This ensures these professionals are familiar with the current transport circumstances and human-centric needs and priorities of Gauteng commuters, having the insight and experience to advise which elements of the system should be prioritised to positively transform Gauteng's PT services.

EC2: Candidates may not be under the age of 18 years old. This ensures the project remains low-risk and that the project remains ethical by only interviewing independent persons.

3.7.2.4.2 Phase 2 – Quantitative surveys

3.7.2.4.2.1 Inclusion criteria

The IC for the quantitative surveys are as follows:

IC1: The candidate must be both available and willing to participate in the study. Therefore, prior to distributing a survey, candidates must be asked whether they have the time, understanding and enthusiasm to complete the survey with their full attention, without being distracted or needing to leave during. All candidates have a choice whether or not they would like to participate in the study: the researcher may only give them a survey if they have shown interest. Sample participants can be incentivised to form the sample by including them in a lucky draw or offering them a closed sweet or snack to thank them for choosing to participate in the study and completing a survey.

IC2: Candidates must have made use of Gauteng PT service in the last three years (i.e. since the beginning of 2018) and either continued using these services or moved to private transport. South Africa's GHS is performed every five years by Statistics South Africa, the last of which was conducted in 2018 providing general household information such as population growth, socio-economic data and the types of transport modes used by South Africans. Recent information such as this would be incredibly useful in the quantitative phase of this study, for instance, as a foundation for the selection of sample candidates, sampling design or an accurate, reliable basis for modal splits between various PT modes (South African Government, 2021b). As such, only those who have use PT in the last three years are permitted to form part of the sample in order for the GHS 2018 data to be applicable to the study.

Moreover, this three-year time period ensures all views, opinions and information offered by respondents are relevant to the current state of Gauteng PT services and thus useful to the study. Commuters who once used PT but have moved to private transport more than three years ago may have opinions of Gauteng PT based on their experiences, but these opinions may be outdated and no longer applicable to the study given how much PT has changed in the last three years and the significant impact COVID-19 has had on its operation.

IC3: Users of both PT and private transport are permitted to form part of the sample, so long as they have used Gauteng PT services on a regular basis in the last three years, i.e. since the beginning of 2018. In that way, their travel needs, mode preferences and opinions of PT services are informed by recent personal experiences.

IC4: Candidates must be over the age of 18 years. This ensures that younger candidates are adults and allowed to complete a survey without ethical consent from their parents, while no upper bound exists allowing older citizens using PT to provide insights from their PT experiences.

3.7.2.4.2.2 Exclusion criteria

The EC for the quantitative surveys are as follows:

EC1: The candidate has a vested interest in promoting a particular PT mode and thus carries a clear potential bias in favour of one mode over the another. Examples include owners, drivers or representatives of a particular travel mode, as well as members of a club or community that promote a specific transportation mode. These candidates are not necessarily commuters who use PT on a daily basis (for whom the surveys are designed), experience PT services from a different context than commuters and would likely carry a resistance to changing the PT system as it is, perceiving that their jobs could be threatened by such reform. Therefore, their information and insights would not be applicable to this study nor align with the intention of the study.

3.7.3 Determining the sample sizes

3.7.3.1 *Phase 1 - Semi-structured, expert interviews*

Determining the sample size for qualitative interviews is arguably quite a controversial topic, given how many factors and considerations are involved and how specific it is to the study of interest. In order to make an informed decision on the sample size for the semi-structured, expert interviews in Phase 1 of this study, this section discusses the factors and considerations involved in determining the sample size for qualitative interviews. A decision is also made as to how the sample size for the expert interviews in Phase 1 is determined.

3.7.3.1.1 Introduction

It is known that the success of qualitative research depends on the amount of good quality data available, meaning the level of detail obtained from a sample is far more important than how many responses are collected (Townsend, 2013; O'Reilly & Parker, 2013; Fox, 2009). To demonstrate the rigor and quality of their research, these researchers are advised to maintain a high level of transparency throughout the study regarding how their sample size was chosen and how their data is analysed and interpreted (Vasileiou, Barnett, Thorpe & Young, 2018; Levitt, 2017; Morrow, 2007; Morse, 1995).

Quite often, certain limitations such as time, resources and availability of respondents arise, causing the researcher to have to select a sample size or sampling strategy that is not as precise as they hoped (Strauss & Corbin, 1998). Even so, all candidates should be specifically chosen as representatives of the sample, ensuring the findings resulting from the analysed data caters for the variety of perspectives and insights held by the sample (O'Reilly & Parker, 2013; Fox, 2009). If it is the researcher's goal to enhance the diversity of the sample, candidates with as many different views as possible should be included in the sample, even if these views do not align with the norm (Fox, 2009). At any point in the study, collecting new insights and

understandings into the field being studied should remain the researcher's priority, thus gathering a comprehensive understanding of how people perceive the topic of interest (Fox, 2009).

3.7.3.1.2 Factors involved in determining the sample size for qualitative interviews

Scholars suggest that a multitude of different factors are involved when determining the sample size for qualitative research. The most frequent approach to justify sample size sufficiency related to data saturation (55%), followed by factors more specific to the study (23%) such as satisfying the research design requirements, the nature of the study and the quantity of data that has been gathered. Next, factors unrelated to the study (12%) were noted as justifications, including the findings of previous research as well as frameworks and guidelines for sample size calculation (Vasileiou, Barnett, Thorpe & Young, 2018).

Among these considerations, scholars point out other factors involved in sample size calculation. Relating to the study at hand, the scope, nature of the research topic and research design all play a role in determining the qualitative sample size. More specific to data collection, the data quality, the data collection strategies utilised and resource constraints such as finances or time are considered. (Morse, 2000).

3.7.3.1.3 Determining the sample size for Phase 1

Scholars recommend that a minimum sample size of 5 participants and a maximum sample size of 25 participants are employed for a semi-structured qualitative interview (Creswell, 2007; Symon & Cassell, 2012). While 5 to 25 participants are recommended for purely *qualitative* research, this study leans on *quantitative* research and utilises qualitative research only to shed light on important yet unseen insights that would both expand the scope and enhance the reliability of the quantitative research.

Therefore, while considering the advice of Creswell (2007) and Saunders (2012), it seems plausible that a total of **six qualitative interviews** (three with PT experts and three with HCD experts) are conducted initially to search for new and important insights. Then, aligning with the explorative nature of the study, an additional three interviews with each type of expert (indicating a maximum total of 12 qualitative interviews) if the researcher still requires a better understanding of the topic or how to successfully construct the quantitative surveys in order to collect data that meets the study's aim.

3.7.3.2 *Phase 2 – Quantitative, correlation-based surveys*

3.7.3.2.1 Equations for determining survey sample size

Various equations are offered by scholars to determine the sample size for a quantitative research study. This section summarises the equations, variables and methods involved in calculating the sample size, after which the validity of equations to this study are compared.

3.7.3.2.1.1 Summary of equations

Cochran (2007) and Ali (2014) suggest using Equation 1 to determine the research sample size.

$$n_0 = \frac{z^2 \times p(1-p)}{e^2} \tag{1}$$

Where,

- n_0 = minimum sample size

- z = two-tailed area under the normal distribution curve resulting from a selected level of confidence, generating the standard error where z = 1.96 for a 95% confidence level and z = 1.94 for a 90% confidence level

- p = proportion of the target population with the desired characteristics. If a proportion value is not available, set p = 0.5 (50%) to maximise the potential sample size

- e = acceptable sampling error, generally 0.05 (5%)

Louangrath (2015) suggests using Equation 2 to calculate the sample size, which is similar to Equation 1 except the estimated population standard deviation (σ) is used instead of the population proportion (p).

$$n_0 = \frac{z^2 \times \sigma^2}{e^2} \tag{2}$$

Another common sample size formula is offered by Etikan and Babatope (2019) in Equation 3, relevant to survey studies from a limited population size.

$$n_0 = \frac{N \times X}{(X + N - 1)} \tag{3}$$

with

$$X = \frac{Z_{\alpha/2}{}^2 \times p(1-p)}{MOE^2}$$

Where,

- n_0 = minimum sample size

- p = proportion of the target population with the desired characteristics. If a proportion value is not available, set p = 0.5 (50%) to maximise the potential sample size

- N = population size

- $Z_{\alpha/2}$ = critical value of normal distribution at α/2. With a 95% confidence level, α = 0.05 and z = 1.96

- MOE = margin of error, usually 0.05 (5%)

Equation 4 below is suggested by Krejcie and Morgan (1970) to calculate the sample size.

$$s = \frac{X_2 \times N \times p(1-p)}{d^2(N-1) + X_2 \times p(1-p)} \tag{4}$$

Where,

- s = required sample size
- X_2 = table value of chi-squared distribution for 1 degree of freedom at the desired confidence level
- N = population size
- p = proportion of the target population with the desired characteristics. If a proportion value is not available, set p = 0.5 (50%) to maximise the potential sample size
- d = degree of accuracy, usually 0.05 (5%)

3.7.3.2.1.2 Evaluation of equations

Equation 1 is the simplest way to determine the research sample size, as the population proportion with the desired attributes (p) can either be determined from research or set to 0.5 (50%) to maximise the potential sample size. However, the simplest equation may not yield the most reliable answer. *Equation 2* is similar to Equation 1, except the estimated population standard deviation (σ) must be determined. No recommendations are given on how to estimate σ, meaning any estimations of σ must be determined from research; this is likely to be more challenging to attain than p and may not be precise enough to make an accurate sample size estimation.

While *Equation 3* is embedded and lengthier, it requires the same parameters as the latter and the values of $Z_{\alpha/2}$ and MOE can be determined in the same way. The population size (N) can be found simply through research. Considering *Equation 4*, the parameter *d* translates to the MOE or *e* parameters of the other equations, so nearly the same parameters are required to calculate the sample size. However, the researcher must have experience in reading and interpreting a chi-squared table which could complicate the sample size determination.

3.7.3.2.1.3 Select sampling equations

After due consideration, Equation 3 was selected to calculate the sample size for the second phase of research, since the researcher is more familiar with normal distribution graphs, the parameters are simple to attain and the study considers a limited population size of transport users. In the following section, the sampling parameters to populate Equation 3 was chosen with the necessary justification and the sample size for Phase 2 was determined.

3.7.3.2.2 Selecting sampling parameters

Each one of the sampling parameters in Equation 3 are now described and selected. Clear justification relating to the choice of each sampling parameter is provided in context of the study.

3.7.3.2.2.1 Parameter 1 – Level of confidence, LOC

A much greater sample size can be expected for the quantitative surveys compared to the qualitative interviews, as far more responses would be required from a vast variety of commuters to notice trends and establish which HCPTD principles are more palatable. According to SurveyMonkey (2021a), as the sample size rises, so does the level of confidence (LOC), implying a lower MOE. The researcher aims to be as confident as possible that the same sample results would emerge if the surveys were reapplied (given this directly affects the validity of the study), while a lower MOE is desired to ensure as little errors or biases are present in the sample responses or surveys. Therefore, in order to raise the quality, accuracy and reliability of the survey results, a **95% LOC** (0.95 confidence coefficient) is chosen for second phase of research.

3.7.3.2.2.2 Parameter 2 – Margin of error, MOE

According to SurveyMonkey (2021a), the MOE corresponds to the chosen LOC. Therefore, a **5% MOE** was selected for Phase 2.

3.7.3.2.2.3 Parameter 3 – Population size, N

Here, *N* relates to the population size of the Gauteng Province in South Africa where quantitative data is collected from commuters. It should be noted that only participants over the age of 18 years were permitted to participate in the study. There are 39,806,445 people over the age of 18 in South Africa (World Population Review, 2021), where Gauteng makes up 26% of South Africa's population. Thus, the population size of adults in Gauteng is:

$$N = 39{,}806{,}445 \times 0.26 \approx 10{,}349{,}676 \ people$$

3.7.3.2.2.4 Parameter 4 – Proportion of target population, p

Referring to the GHS population survey in 2018, the sample parameter p indicates the proportion of Gauteng Province citizens over the age of 18 years making use of PT services in 2018. Thus, p excludes those who have left the PT system since 2018, as there would be no way of accurately determining this portion of commuters due to the impact of COVID-19 and how much the South African PT system has evolved since 2018. As a result, the data provided by the GHS 2018 surveys reflects the most accurate proportion of PT users in the GP and is thus the most reliable estimate to use for the present date, as no reliable sources of data have been provided on this subject since.

Figure 6 was taken from official document summarising the GHS 2018 survey results, indicating the proportions of households who made use of PT (i.e. MBT, BRT and trains) per province before the survey. For the GP, a total proportion of 53.8% existed in 2018 (STATS SA, 2018). Therefore, **p = 0.538**: the most precise estimate of PT users in the GP in 2018 over the age of 18 years old.
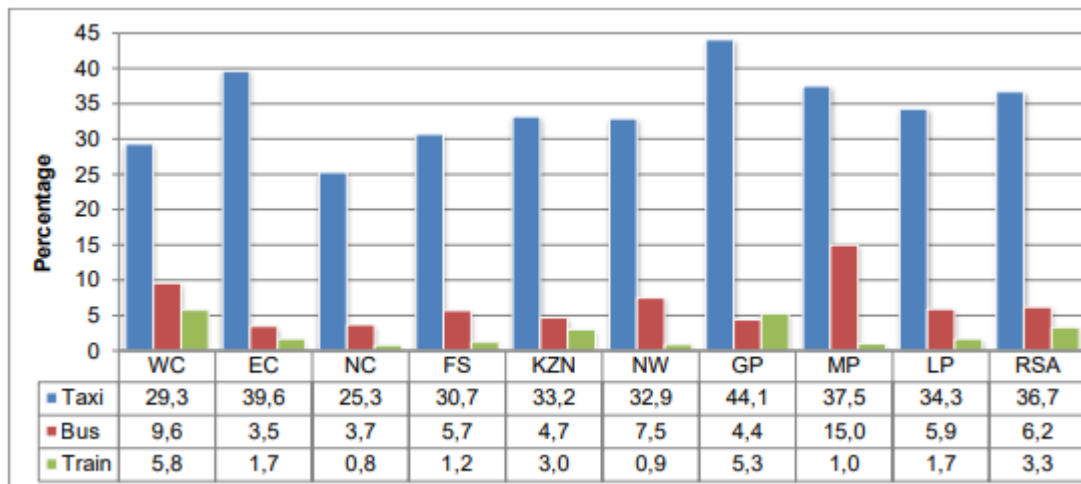
Figure 6: Modal split proportions of public transport in Gauteng in 2018

3.7.3.2.2.5 Calculating the sample size

The sampling parameters for Equation 3 are summarised as follows:

- LOC = 0.95 (95%) → $Z_{\alpha/2}$ = 1.96 (Etikan & Babatope, 2019)

- MOE = 0.05 (5%)

- N = 10,349,676 people

- p = 0.538 (53.8%)

Firstly, the value of X is determined:

$$X = \frac{{Z_{\alpha/2}}^2 \times p(1-p)}{MOE^2} = \frac{(1.96)^2 \times 0.538(1-0.538)}{(0.05)^2} = 381.941\ldots$$

Then, n_0 is calculated using Equation 3:

$$n_0 = \frac{N \times X}{(X+N-1)} = \frac{10,349,676 \times 381.941\ldots}{(381.941\ldots + 10,349,676 - 1)} = 381.932 \approx 382\ responses\ required$$

As such, the researcher requires a minimum of 382 survey responses in the second phase of research to ensure an adequate amount of reliable data is collected and results are within a 95% LOC are produced. This also ensures errors and biases resulting from the sample selection are mitigated (Survey Monkey, 2021; Ali, 2014; Taherdoost, 2016).

3.7.3.2.3 Sample size discussion

The sample size was set at 300 survey responses. This sample size was determined by using sample size calculations from Equation 3, further enriched with insights from journal article publications of research studies conducted in a similar field of study in South Africa. Moreover, this sample size was reached by considering the unique constraints of the study and the context for primary research data collection.

Equation 3's calculations resulted in a suggested minimum sample size of 382 survey responses, as shown above. The sample population, N, initially included those under 18 years' old, resulting in N = 15, 488,137 people (South African Market Insights, 2020). Later, an adjustment was made to only include those over 18 years' old (see section *Parameter 3 – Population size, N*, above), as only these Gauteng citizens could be included in the sample, resulting in a final value of N = 10,349,676 people. Interestingly, such a significant change in N did not *at all* change the result of Equation 3, meaning n_0 remained 382 responses.

While Equation 3 did consider the population of adult PT users in Gauteng and an estimated proportion of the population using PT, it is arguably a purely mathematical sample size determination. Thus, enriching this calculation with unique considerations such as the impact of COVID-19 and the researcher's capabilities would offer a more manageable sample size. In order to understand the role of sample size in a South African PT study, the sampling design of South African research studies with a similar nature to this study were considered for guidance on what would be a viable sample size.

The sample size of 608 used by Lombard and Hugo (2002) was selected for consideration, as the study was key to the literature review and these scholars deployed a similar data collection approach for their consumer preference surveys in the field of PT. The study was based in Cape Town. However, the sample determination for this study was impacted by the fact that this was a two-year long study (2001 – 2002), and their survey contained only 15 questions, as opposed to the 24 questions in this study's survey.

In contrast to the sample size of 608 put forth by Lombard and Hugo (2002), a more recent civil engineering study by Blersch, Shrand and Ronnie (2020) featured a smaller sample size of 104 cross-sectional quantitative surveys which contained a similar body of questions, although these surveys were deployed online. Similar to the study at hand, the study had an exploratory nature and followed a convenience sampling approach.

Other scholars suggested more ambitious sample sizes of between 300 and 1000 survey participants. Luke and Heyns (2019) aimed to measure the service quality of PT modes in Johannesburg by comparing commuter perceptions with their expectations thereof. A quantitative questionnaire with 25 statements was used to collect data in this study, using a 5-point Likert scale (as was used in the majority of questions in this study's survey) as well as convenience sampling approach that is also employed in this study. It should be noted that **trained** research assistants were used to collect specific surveys from waiting commuter at various public transit facilities. Over two years (2016 and 2017) and two separate survey campaigns, a total of 1152 surveys were collected from PT commuters in Johannesburg.

To determine a manageable sample size for this study, the researcher needed to consider the constraints for data collection which includes **limited resources** such as:

- **time** - instead of two years, a maximum of two weeks are available for data collection
- **finances** - since the researcher is a student, a limited amount of money is available for data collection efforts
- **transportation available** - the researcher does not possess a vehicle and must thus travel to data collection site using MaaS or PT services

Additionally, **no research assistants** were hired or available during this study. A DCA was hired merely to assist with the collection and input of quantitative survey data, but only one researcher formed part of the research team. A lack of research assistants also links to limited resource availability. Moreover, **collecting survey data was time consuming** (especially for only two people), involving:

1. Informing prospective participants about the context and aims of the study
2. Distributing a laminated survey and whiteboard marker
3. Participants completing the survey
4. Taking pictures of both sides of the completed survey
5. Sanitising both the laminated survey and whiteboard marker
6. Having participants fill in the informed consent form and COVID-19 contact register
7. Giving participants an incentive to thank them for their help

Linking to this, only five surveys were available at one time and only two people were available to collect and process this data before engaging with a new participant. The COVID-19 pandemic also **restricted the amount of in-person contact**, meaning it was far more challenging to locate potential PT users while in public, in addition to them being more cautious about in-person contact due to fear of virus transmission.

Because the study is explorative in nature and follows a convenience sampling design, it seems reasonable to lower the sample size to the extent that it is manageable for the researcher and DCA to attain. According to the data collection constraints discussed and the guidance of Cruz-Cárdenas (2017), a minimum number of **300 survey responses** was decided upon for the second phase quantitative data collection as a conservative yet manageable goal.

3.8 Research approach

The procedure followed during the study to collect the desired data, answer the research questions and achieve the research objectives is as follows:

Step 1: Construct the two qualitative interview guides based on the interview objectives developed for either expert type, ensuring that the guidance and recommendations synthesised from scholarly research is effectively utilised.

Step 2: Synthesise a list of PT- and HCD principles, respectively, from primary literature. These principles were used as a framework to construct the initial principles tested in Phase 2. Note that there is no limit to the amount of principles that should be synthesised from primary research – it is ideal to have as many relevant principles as possible to refer to during the interviews.

Step 3: Conduct a pilot interview for each one of the interview types to enhance interviewing skills, evaluate the timing of the interview and assess whether specific questions must be added or removed in order to collect better insights from experts.

Step 4: Identify three PT experts and three HCD experts that meets the given IC and EC. Contact these individuals over email or telephonically and invite them to participate in the study, informing them what the study aims to achieve, communicating the interview details and sending the appropriate interview guide as an introduction to what these experts can expect. Given the snowball sampling approach chosen for Phase 1, other experts with the necessary expertise can be recruited afterwards through the personal reference of the initial interview candidates – ensure these recommended experts also meet the IC and EC decided upon.

Step 5: Conduct a total of at least six qualitative interviews with PT experts and HCD experts (more if additional insight is still required. The researcher should study scholarly interview guidelines sufficiently before the interview to enhance the quality and flow of the interview. It should be noted that insights may arise in these interviews that were not originally considered: the exploratory nature of the study allows for this type of flexibility, allowing new insights and considerations to be explored further in the subsequent research phase.

Step 6: Analyse the interviews conducted. This includes transcribing each interview and applying qualitative thematic content analysis method to organise the interview content in a list of qualitative interview themes and related subthemes, which fall under their appropriate themes. Scholarly research on qualitative thematic content analysis must thus be conducted and synthesised so that the researcher follows clear,

reliable guidelines on how to effectively utilise this qualitative data in a way that serves the research objectives.

Step 7: Based on expert insights obtained during the qualitative interviews and the literature-based principles (see section 2.4.3), define a list of **initial PT- and HCD principles**, respectively, which are:

1. the most applicable to the Gauteng's local transport context and its PT priorities,
2. the most applicable to the study's context, aims and research questions, and
3. the most capable of promoting elevated customer satisfaction, improved service provision and operational success based on current Gauteng commuter needs and local transport prioritises

These principles are comprised of both literature and new insights gained from the qualitative interviews, as some insights gained may be more relevant to Gauteng and its current transport context. Only principles which were shown to be relevant by experts and global literature, important to consider *and* applicable to Gauteng should be defined to reduce the effort expended in Phase 2 and in turn limit the survey length.

Given that only three to five final HCPTD principles are ultimately chosen and fully developed after the quantitative survey analysis, the development of a maximum of **eight initial principles** for each study construct is considered sufficient. The significance of each principle is then probed during the second phase of data collection to assess which principles can be utilised to define the final HCPTD principles, based on their relevance to Gauteng commuters and local transport authorities.

Step 8: Construct the quantitative correlation-based surveys to test which initial principles are the most desirable for commuters, capable of meeting their core travel needs and how they would respond if these principles were integrated into Gauteng PT design. This would enable the selection of viable initial HCD- and PT principles that can be fully developed, based on quantitative commuter responses. The design of these surveys should be based on both the survey objectives as well as the list of initial HCD- and PT principles developed, respectively. In addition, scholarly guidance on effectively designing quantitative surveys merged with a correlation study should be utilised during survey design process to improve the quality and validity of data collected during the second data collection phase.

Step 9: Conduct a pilot study of 10 responses each for both the in-person- and digital survey types, respectively. The goal of this study is to assess whether the phrasing and sequence of survey questions is effective in collecting the desired information, remove or add in specific questions based on pilot responses and give the researcher an opportunity to restructure and refine the interview to improve the likelihood of gathering rich, reliable data.

Step 10: Collect the required number of responses (i.e. 300 surveys) from PT users in the GP (using the in-person- and digital interviews developed) who align with the IC and EC indicated, precisely following the

demographic split calculated in section 3.10.6. Specific PT users (say MBT commuters) can be located at or nearby their appropriate PT service hubs (say at or in the area surrounding taxi ranks). Note that in-person data collection can *only* be conducted if the COVID-19 protocols discussed are strictly adhered to, where the researcher should ensure no person is at put at risk of virus transmission. Scholarly guidelines advising how to collect reliable, complete and high-quality data during survey data collection should also be studied prior to collecting data and followed during to enhance the internal and external validity of the study results.

Step 11: Input the numerical data collected into a data management software such as MS Excel™ and organise the data effectively. Data can be organised by, for instance, using colour coding, several worksheets and data structures such as tables to effectively summarise and present the numerical data collected.

Step 12: Conduct primary research and synthesise a list of quantitative, statistical methods that are fit for analysing and interpreting the significance of the numerical data collected. These methods should align with the MM nature of the study, be possible to apply given the researcher's quantitative skills, and necessary in terms of difficulty, given the type of data acquired and what the study aims to achieve. In addition, the methods chosen should be capable of meeting the survey objectives.

Step 13: Select, with justification, the best statistical method for processing the data collected and achieving the survey objectives, thus enabling the researcher to achieve the research objectives and answer the research questions.

Step 14: Analyse the numerical data with the statistical method chosen and present the data in a statistical and graphical format, showing the main statistical parameters that result and illustrating the presence of the relationships with graphs and equations.

Step 15: Interpret the results of the statistical analysis by discussing their significance in context of the study. Also comment on what the results imply about the presentation of the final HCPTD principles and answering of the research questions.

Step 16: Based on the results and interpretation of the second phase of research, select between three and five initial principles that are capable of promoting elevated customer satisfaction as well as improving the service quality and operational success of Gauteng PT services.

Step 17: Fully develop and present the final HCPTD principles to stand as concise, independent and self-explanatory principles of HCPTD that can be utilised by Gauteng PT authorities and service providers to better satisfy commuters and improve the operational success of Gauteng PT services.

3.9 Ethical considerations

This section of the study is dedicated to understanding the principles of ethical research and applying them to the unique context of this study to ensure the research is ethical in nature. Furthermore, consideration should be given on how project benefits can be enhanced and risks of harm to stakeholders are reduced in the research process. Issues relating to the confidentiality and privacy of information are also discussed with reference to this study, including the process of acquiring informed consent from respondents to make use of their personal data.

3.9.1 Principles of ethical research

The principles of ethical research are discussed here to cultivate a foundational understanding of ethical thinking prior to data collection. These principles are synthesised and rephrased from primary research and used during data collection to guide the choices, actions and behaviour of the researcher to remain ethical.

3.9.2 Expected risks and benefits of research

The expected risks and benefits that could arise during the collection, analysis and application of data collected in this study are discussed in this section. Informed estimations are made to evaluate the extent of potential risks and benefits, estimating how risks would affect both the ethicality of the research and the well-being of participants as well as how the potential benefits could serve the Gauteng PT community.

Consideration is also given on how to mitigate expected risks and enhance potential benefits such that the study is beneficent and serves the best interest of society, utilising the principles of ethical research discussed above as a means of addressing all potential research risks to enhance the ethicality of the study.

3.9.2.1 *Potential risks*

3.9.2.1.1 Phase 1 – Qualitative interviews

The entire data collection procedure in this research phase takes place in the researcher's home, as interviews are to be conducted online over Zoom Meetings™. Thus, a low degree of potential risk is expected. While this may be so, potential risks emerging from this research phase are discussed below.

3.9.2.1.1.1 Risk 1 – Unclear sound or poor sound quality

Due to either the microphone or the Zoom™ audio settings, there exists a risk that the meeting recording does not properly capture the words of the expert being interviewed. The researcher may not be aware of this during the interview and may have to request that another interview is conducted once the poor sound quality is realised.

Intervention A: Before the interview begins, the Zoom™ audio settings of both the researcher and interviewee should be checked to ensure the correct microphone type is used.

Intervention B: Conduct a sound check for both interview parties before the interview begins to ensure the parties can hear one another clearly.

Intervention C: The researcher should request that the interviewee speaks as close to the microphone as necessary for the sound quality to be optimised.

Intervention D: Place a cell phone recorder nearby the soundbar of the researcher's laptop to ensure the audio of the interview is recorded on a different device and at a desirable quality.

3.9.2.1.1.2 Risk 2 – Poor internet connection during interview

There is a likelihood that either the researcher or interviewee may have a poor connection to the internet during the interview, causing the video to lag and the audio to be unclear.

Intervention A: Ensure that both interview parties are sitting as nearby to a source of internet as possible during the interview.

Intervention B: Conduct interviews at a time when the least number of people are using the internet. If too many people are using the internet while the interview is being conducted, this may cause the meeting to have a lower bandwidth priority and thus lag extensively. To avoid this, conduct the interviews as early in the day as possible.

Intervention C: If the researcher notes that the interview video or audio is still lagging even when the interview is being conducted at a low peak internet time, request that both parties turn of their video on Zoom Meetings™. This enhances the bandwidth of the meeting and thus the video's sound quality.

3.9.2.1.1.3 Risk 3 – Loss or corruption of data

In any research project there exists the risk of collected data becoming lost or corrupted, even when a supposedly reliable device is used. Thus, the recorded interview data may either become lost, accidentally deleted, or corrupted in its original storage file. Additionally, devices or storage platforms may not have the necessary space to accommodate several large video files of around an hour each, implying a risk of interviews not saving correctly is probable.

Intervention A: Record the qualitative interviews both on Zoom Meetings™ and with a phone recorder so the information is available and can be transcribed even if the recording meeting is corrupted or lost.

Intervention B: The recorded interviews were saved both on the researcher's laptop and on Google Drive™ to ensure the data is never lost nor corrupted during the study.

Intervention C: Before conducting each interview, ensure sufficient space is available both on the researcher's laptop and on Google Drive™ to ensure the recorded interviews can be safely and securely saved and stored during the study.

3.9.2.1.1.4 Risk 4 – Interview runs over time

There is a possibility that an interview may run over time, meaning the interviewee may need to leave the meeting and the researcher cannot ask all the questions needing to be asked.

Intervention A: Prioritise which questions *must* be asked versus those that are not that important, marking unimportant questions with a "*" and asking these if enough time is left. Avoid asking unnecessary follow-up questions.

Intervention B: Study and closely follow the qualitative interview guidelines synthesised in the research design section to ensure the interview complies with professional standards and is thus completed on time.

Intervention C: Estimate the amount of time required for each main interview question to avoid going over time in each question.

Intervention D: In the event that an interview *does* go over time and the interviewee needs to leave, ask the interviewee if they would mind answering a few more important questions over email. That way, if this request is accepted, the meeting remains 60 minutes and the researcher can ask all the desired questions.

3.9.2.1.1.5 Risk 5 – Confidentiality of participants and/or company information is breached

While the researcher is not asking for any personal information that can be traced back to the participant, employer or company, there exists the risk that the confidentiality of this information can be breached.

Intervention A: The only personal information required is the participant's contact details, job title and field of expertise. No other personal information will be asked to ensure nothing can be traced back to the participant or their company.

Intervention B: The name of the company, employer or participant will not be written anywhere in the study's report. For reference purposes during data analysis and comparison, participants will be assigned a random ID code to protect the privacy of their information, for instance *PT Expert A.*

Intervention C: Email correspondence will be fitted with a *Confidentiality* setting so that no emails can be forwarded, copied, printed or downloads, while a one-month expiration date for transcription edits and a SMS passcode for private access by only the researcher and respective participants are used. Once transcription edits are returned and applied, all email threads will be deleted permanently.

Intervention D: Phone numbers will be used only to make initial contact with prospective participants, after which they will be completed erased from the researcher's phone and records. Email addresses will also be deleted once correspondence with participants has been completed. None of these contact details will be shared with anyone but the researcher and permanently deleted after the interview, unless participants

give the researcher permission to inform them of the study's results once it is done, in which case the address will be deleted then.

Intervention E: Send the proposed interview guides to participants with the recruitment email and ask them to inform the researcher which questions they can and cannot answer. If specified, these questions will not be posed to participants.

3.9.2.1.2 Phase 2 – Quantitative surveys

3.9.2.1.2.1 Risk 1 – Virus transmission

During second phase, quantitative data collection where in-person surveys are distributed, there is exists a risk that the COVID-19 virus could be transmitted either to the researcher or to a sample participant. Transmission could occur either during conversation or when the researcher and participant has touched the same surface without sanitising it. Preventing virus transmission enables the study to fulfil the ethical principles of "Respect for persons" and "Beneficence and non-maleficence", given that their rights to health and safety are being provided for and information is being acquired in a way that offers more benefits than harm to participants, respectively.

Intervention A: Strictly adhere to the COVID-19 regulations discussed in the research limitations section. This includes the wearing of protective cloth masks when in public, social distancing at minimum of 1.5 m and prohibiting people from touching any surface that has not been sanitised.

Intervention B: Instead of using paper or plastic to collect data on and risking virus transmission, use a laminated survey sheet. Responses can be completed using a whiteboard marker, after which pictures of survey responses are taken with a cell phone. Survey sheets and markers are then sanitised after each use.

Intervention C: Only approach one person at a time, ideally when they are isolated from others. This limits the amount of attention drawn to the researcher and participant as well as the amount of people occupying the same space, thus making participants feel more comfortable and mitigating all virus-related risks.

3.9.2.1.2.2 Risk 2 – Cell phone/s being stolen

While collecting data from users of PT in public, there exists a risk that a cell phone is stolen when taking pictures of survey responses, given that it is regularly visible during data collection and could thus attract attention.

Intervention A: Hire a friend a DCA with the purpose of protecting the researcher and cell phones, as well as assisting with the collection of data by consulting potential respondents. It is preferrable that this person is a male, arguably because men would more willing to be vulnerable in public and have the presence and stature to provide adequate protection.

Intervention B: After each survey response is captured, immediately store cell phones away in a satchel or bag with a closed zip. Only take the phone out when absolutely necessary.

3.9.2.1.2.3 Risk 3 – Researcher or assistant is harmed in public

Given that a cell phone and other electronic equipment is carried around during data collection and the researcher and the DCA are vulnerable when in pubic, there is a risk that either person could be harmed when collecting data.

Intervention A: Refrain from collecting data in areas which are poorly lit, isolated from the public and where the researcher and assistant are particularly vulnerable.

Intervention B: When collecting data at busy PT hubs such as train stations, approach management at the hub with ethical clearance and enquire whether an enclosed area (such as a glass booth) is available to use where the researcher and DCA can sit safely and collect data from participants.

Intervention C: Keep the cell phones stored in a secure area that is always out of sight except when data is collected from people. Both the researcher and assistant should always remain alert when cell phones are visible for any criminal activity and report concerns to local management if applicable.

3.9.2.1.2.4 Risk 4 – Loss or corruption of data

In any research project there exists the risk of collected data becoming lost or corrupted, even when a supposedly reliable device is used. In this research phase, there is a risk that data is lost or becomes corrupted on cell phones (where all survey responses are captured) or the researcher's laptop.

Intervention A: Store all survey response pictures both on the researcher's laptop and on Google Drive™ to ensure the survey data is always available during the course of the study, even in the event the laptop or cell phone becomes unusable, or data somehow becomes corrupt.

Intervention B: Charge the cell phones fully before going to collect data in public and ensure the phone's performance is optimised by, for example, deleting unnecessary applications and enhancing its settings.

3.9.2.1.2.5 Risk 5 – Encountering those with diminished autonomy

Relating to the ethical principle of "Respect for persons", there exists the risk of encountering people with diminished autonomy in the form of a mental illness, sickness or past situations where freedom to make individual choices was withheld. Even if these people meet the IC and EC specified, collecting data from these individuals may be risky as they may provide poorly considered responses that negatively affect the internal validity of the study or assault the researcher physically or verbally.

Intervention A: When first approaching the person, provide full, clear information about the study at hand and be sure to respect their rights and dignity even if they are particularly frail.

Intervention B: During the introduction to the study and invitation to participate, establish whether these individuals have the capability of understanding the researcher and provide true, understandable responses to questions. If the individual is found to have diminished autonomy, they must be protected from harm according to the principle of "Respect for persons" and thus not included in the sample. In addition, this would also preserve the internal validity of the data collected, as no false or ambiguous data is collected.

3.9.2.1.2.6 Risk 6 – Desperation for sample respondents

It is already very challenging for researchers to collect in-person data during COVID-19 conditions due to the regulations put into place to protect people's health. This in-person data collection is, however, necessary in this study given that a portion of PT users may be technologically captive or limited financial and thus not be able to access to the online surveys – including these people enhances the external validity of the study's findings. For many reasons, including scarcity of people in public meeting the prescribed IC and EC or fear of virus transmission, it may be difficult to collect the desired number of in-person responses. This may result in the researcher becoming desperate to gather the necessary in-person responses in time to ensure the study's external validity but risk the internal validity of the study.

Intervention A: Given that this study is exploratory in nature and the circumstances of COVID-19 are challenging and unpredictable, the researcher is given the liberty to adjust the percentage of in-person responses to whatever is possible at that stage during research. Any other in-person/digital split is allowed with justification as long as the demographic split calculated in the sample size determination section is followed to enhance the generalisability of the results. Just note that this may lower the study's external validity, as some types of PT users may be excluded due to a limited access to technology or mobile data to access the online surveys.

Intervention B: According to the ethical principle of "Justice" above, each participant must be chosen for a specific reason to be part of the study's sample in order for all participants to be treated fairly during the recruitment process. Therefore, each participant (regardless of how desperate the researcher is) must satisfy the IC and EC for this study and align with the demographic split decided upon.

3.9.2.1.2.7 Risk 7 – Challenges with language and communication

According to the ethical principle of "Informed consent", it is vital to convey information about the study in an understandable way, according to the proficiencies of participants. A significant portion of Gauteng commuters have home languages other than English, indicating that challenges may arise with clearly communicating study information or questions and receiving reliable, informed responses, given their limited vocabulary.

Intervention A: To ensure study information and the survey questions are understood by potential respondents not proficient in speaking or understanding English, the DCA should also be a translator. As such, the assistant must fluently speak at least two of the national languages local to the GP so that any information or questions can be explained clearly to them and clear, reliable responses to questions can be obtained.

Intervention B: Consider translating the surveys into two or three local national languages.

3.9.2.1.2.8 Risk 8 – Minimal inconvenience caused

There is a risk that commuters can miss a trip because they were completing a survey response or be inconvenienced to a small degree from their daily schedules. Furthermore, surveys may take too long for some participants, lowering their interest in participating and possibly causing them to retract their response. Prospective participants may also feel insecure if they are approached, since it may attract the attention of others and induce fear of contracting the COVID-19 virus.

Intervention A: Design surveys so that they only take 5 minutes to complete. This can be done by reducing the number of questions asked to only essential questions, making use of emoticons to encapsulate the emotive responses of participants and only mentioning vital study information to both reduce the time taken to complete a survey response and maintain a participant's interest in the study.

Intervention B: Inform prospective participants that survey responses will only take 5 minutes to complete. That way, people can estimate if they have the time to complete a response and channel their focus into doing so.

Intervention C: Once prospective participants are aware of how long a survey response should take, check and confirm that they can commit to completing a response. Otherwise, people may need to leave halfway through a response and that response must be deleted as it is incomplete.

Intervention D: Only approach one person at a time, ideally when they are isolated from others. This limits the amount of attention drawn to the researcher and participant as well as the amount of people occupying the same space, thus making participants feel more comfortable and mitigating all virus-related risks.

Intervention E: Strictly adhere to the COVID-19 regulations discussed in the research limitations section. This includes the wearing of protective cloth masks when in public, social distancing at minimum of 1.5 m and prohibiting people from touching any surface that has not been sanitised. This may make participants feel more secure and relaxed given that the appropriate regulations are being followed.

3.9.2.2 *Expected benefits*

3.9.2.2.1 Benefit 1 – Providing for human needs

The study aims to investigate the impact of placing human needs at the centre of design thinking in Gauteng PT services, with the hypothesis that doing so will lead to elevated customer satisfaction. If this proven correct, there will be evidence that the incorporation of human-centric thinking into PT design is capable of meeting the needs of Gauteng PT users, having the potential to positively transform Gauteng PT as we know it. The effect of this transformation could result in extensive financial savings due to an optimisation of the existing PT system and a boost in revenue due to more commuters wanting to make use of these services. Therefore, this research serves the ethical principles of:

- "Respect for persons", given that PT users are treated as autonomous persons and their dignity, opinions and choices are both respected and incorporated into the study outcomes
- "Beneficence and non-maleficence", as the study aims to offer extensive benefits to Gauteng's PT system and society, collect data in a fair, ethical way, mitigate all potential risks and enhance expected benefits during the research design process
- "Justice", given that all participants are considered equal in the recruitment process and careful consideration is given as to whom the benefits and risks of the study affect
- "Informed consent", since information is provided to all potential participants in a way that they can comprehend, while not influencing their decisions on whether they would like to participate
- "Confidentiality" and data protection", as participants are informed prior to collecting data how their information is to be used, processed and shared, showing that the privacy of their information is valued and that measures will be taken to protect their data
- "Integrity", by prioritising transparent and honest interactions with all respondents

3.9.2.2.2 Benefit 2 – Promoting integration of transport system

The Gauteng DOT is in the process of integrating the country's PT system, but this could be a challenge given the current state of the system (Shaw, 2006; Barrett, 2004; Brand South Africa, 2015; Van der Westhuizen, 2007; Mostert, 2011). If the research can prove that the inclusion of human-centric thinking into this system is capable of satisfying customers, there is a chance that these findings could simplify and enable the integration of Gauteng's PT system by encouraging PT design centred around the needs and feedback of commuters when developing PT. Integration of Gauteng's PT system suggests further optimisation of the system, effective utilisation of existing transport infrastructure and extensive financial benefit resulting from these optimisations and all commuter needs and operator needs being met due to a cooperative, interconnected PT system (Ibrahim, 2003; Land Transport Authority, 1996).

3.9.2.2.3 Benefit 3 – Contributing to research field

While it may be possible that incorporation of human-centric thinking into Gauteng's PT design may be capable of better satisfying customers and improving the service quality and operational success of these services, there is also chance that it may not. As far as the researcher is aware, there may be other factors that affect a commuter's satisfaction with PT services in Gauteng. Thus, even *if* the study's hypothesis is proven incorrect, this study contributes to Gauteng transportation development and HCD by illuminating how to fulfil the needs of local commuters and customers, and improve the service quality and operational success of these PT services. The study's findings or recommendations for further research may appeal to another scholar in the field and encourage certain aspects of this research to be studied further, thus carrying the potential for further research to emerge on the study topic.

Conversely, if the research hypothesis is proven correct, this study provides evidence that incorporating the HCPTD principles developed into Gauteng's PT system is capable of promoting elevated customer satisfaction *and* is, in turn, capable of improving the operational success of the system. This evidence can be used as a building block for related studies to further apply the significance of these principles for the benefit of Gauteng commuters. In addition, the findings can be utilised by other scholars or Gauteng's DoT to conduct larger studies across the country in order to better generalise these findings, i.e. investigate whether these findings are applicable the whole of South Africa. Thus, whether the study's hypothesis is proven or disproven, it carries the potential for further research and contributes to the associated research field.

3.9.2.2.4 Enhancing the expected benefits

Aligning with the ethical principle of "Beneficence and non-maleficence", one important part of improving the ethicality of a study is considering how the expected benefits can be enhanced. In the context of this study, the researcher has considered three different measures to enhance the benefits the research could offer the South African society:

Measure A: Taking steps to maintain high internal- and external validity

The term *validity* describes the degree to which the expected results vary from the observed information (Louangrath, 2015), meaning a study's findings are valid if the results are either the same or vary to a small degree from the observed information. Arguably, a study's validity is thus an important part of ensuring a study's findings are considered dependable and valid in the eyes of the associated research community and the study's moderators, as it indicates how nearby the findings are from what is *actually* occurring in the

target population. For this reason, it is important to design the research and take steps to ensure the study maintains high internal- and external validity, in order for the study to be taken seriously by the research community and utilised to benefit Gauteng's transportation.

A study's *internal* validity is affect by the extent of bias, poor survey responses or language barriers present in data collection, thus risking that responses don't accurately reflect a person's true views about the topic at hand (Fink, 2003; Price & Murnan, 2004). The researcher aims to improve the study's internal validity by:

- Minimising any bias present in research design or data collection, resulting either from the researcher or sample participants. This can be done by asking experts to provide information about study aspects the researcher is uncertain about and basing all statements, decisions and design on primary research literature.

- Designing research instruments precisely and effectively to collect the data required from each phase of research, basing the design on the instrument objectives and achieving the study objectives.

- Gathering accurate and complete research instrument responses that reflect each participant's true views and beliefs. This can be achieved by making the effort to ensure participants feel comfortable and welcome in the researcher's presence as well as interested enough in the study, so enough time is taken to provide informed responses that encapsulate their true opinions.

- Dissolve any potential language barriers by utilising the translation ability of the DCA. This would likely make ethnic sample participants feel more included and welcome, allowing them to share their views and participate in the study by using their own native language. In turn, this would likely enhance the quality and accuracy of the data collected.

A study with good *external* validity correctly accurately represents the views of the sample population, implying the study can be generalised to the entire sample population (Fink, 2003). Conducting a proper sampling process, collecting enough research instrument responses and including subjects who meet the study's IC and EC criteria are measures to enhance a study's external validity (Price et. al., 2004). It should be noted that the researcher can only collect data in and around Johannesburg in the GP, implying the study's findings cannot be generalised to the entire South Africa. While this may lower the study's external validity, other measures can be taken to enhance the external validity where possible:

- Conduct and present a well-informed, logically structured research design that is relevant to the study's context, capable of collecting the data desired to achieve the study outcomes and based on primary research. Arguably, the quality of the research design directly affects the quality of the

sampling process, research instruments and thus the data collected, meaning it should be a reliable foundation for the study.

- Conduct a proper, well-structured sampling process to establish who should be included in the study sample to collect the data desired. Sampling should be either based on primary research from scholars or be adequately justified in context of the study's research design.
- Do whatever is necessary to collect at least the minimum number of interview- and survey responses specified, while ensuring high ethical standards are maintained.
- Only include people in the study's samples who meet the respective IC and EC specified.

Measure B: Enhancing ethicality of the study

Arguably, a study with high ethical standards is taken more seriously by the research community and study moderators, as it respects the rights of sample participants and collects data in a fair, confidential way. It is likely that the research community would have greater respect for the study if its ethicality is maintained and careful consideration is made how to protect the information of respondents. A high ethical standard can be maintain in this study by:

- Consistently referring to, following and applying the principles of ethical research (discussed in section 12.1) during research instrument design, data collection, data analysis and the reporting of the study's results
- Giving careful thought as to how the privacy of participant's information can be respected and protected
- Following an informed consent process during data collection (discussed in the next section)
- Taking steps to mitigate potential risks and enhance expected benefits of the study
- Maintaining transparency and honesty throughout the research process

Measure C: Producing a high-quality study

One way of appealing to the associated research community and study moderators is by ensuring the structure, content and academic rigor displayed in the study is of excellent quality. When the study is seen as professional and its results dependable, it is, arguably, more likely that the study's findings will be accepted and promoted by the research community, in turn allowing the benefits offered by the study to be seen and utilised by scholars in related fields. Such an academic standard can be achieved by:

- Displaying excellent academic rigor in the justification of research decisions, the progression of arguments and the consistency of academic aspects such as referencing and synthesis of primary research

- Ensure the report structure is logical, easy to follow and best presents the vast amount of information discussed in the study

- Only providing information relevant to the study and necessary to discuss

- Applying all synthesised primary research effectively so that it serves the study's outcomes

- Professional, creative use of language, punctuation and functionality of the writing software

- Carefully following any synthesised guidelines or recommendations provided by scholars during research instrument design, data collection and data analysis

- Design research instruments in such a way that it gathers the data required and meets both the instrument and study objectives

- Excellent time planning during the research process

- Clear and precise definitions of the research problem, questions, hypothesis, aim and objectives

- Developing a well-structured, effective and apt research design that aligns with the study's objectives and is relevant to the study's context

3.9.3 Managing withdrawal of participants and their data

The researcher devotes to making participants feel comfortable and informed from the time they are recruited until after they are interviewed. This is the main benefit of conducting Zoom™ interviews in Phase 1, as participants can reply to the recruitment email in their own time as well as be interviewed in the comfort of their own home or office. This enhances their sense of comfort by giving them sufficient space and time to do what works best for them in their likely busy schedules.

If a participant no longer wants to participate in the study at any point during data collection (either before, during or after the interview or survey), they will be allowed to do so without feeling any guilt or pressure for their choice. Furthermore, all data collected from a withdrawn participant will be deleted for good from the researcher's possession and will be not incorporated into the research.

3.9.4 Informed consent and confidentiality of information

This section considers how informed consent was obtained from sample participants in alignment with the ethical principle of "Informed consent", while also considering how the confidentiality of participant's information can be safeguarded to serve the ethical principle of "Confidentiality and data protection". A data collection procedure to obtain informed consent is developed and confidentiality measures to protect the privacy of participant information are discussed to ensure the study aligns with the above-stated ethical principles.

3.9.4.1 *Informed consent procedure*

According to City (2021), the first step to obtaining informed consent is providing *information* about a study. In the qualitative interviews (Phase 1), information is provided both over emai when requesting an expert's participation in the study and before the interview commences, while information is provided to PT users during the quantitative survey collection (Phase 2) on approach when being invited to participate in the study. The following information is provided to potential sample participants about the study:

1. Name, surname, academic position and academic institution of researcher
2. Research problem – what prompted the researcher to conduct this research?
3. Research aim – what does the study hope to achieve?
4. Research process – summary of MM research design (if applicable) as well as description and purpose of the two main phases of the study
5. Duration of study and outline of the two main phases
6. Potential risks of study
7. Expected benefits of study
8. Create awareness that participation in study is voluntary and that person can decide to leave at any point during research
9. Inform person of incentives for participation
10. Inform person how their data is used and how it will be protected

Next, the information above must be provided in an *understandable* way according the proficiencies of the participant. This implies the same information can be shared with either research sample but must be carried across in a way they can understand. Therefore, the above information can be shared with experts invited to join the qualitative sample in a professional, academic fashion similar to how it is presented in the study, given that these experts are professionals and can relate to the terminology used. Just note that PT- and HCD experts may not be familiar with the same terminology, so the information may have to be tailor-fitted to their expertise if need be.

However, when inviting commuters to participate in the quantitative sample, the context of the information must be simplified and presented in an interesting and more conversational way, since these people may be less educated than the experts, not understand academia or the meaning of HCD, or simply may not be interested in the study's context due to preference. Therefore, depending on who is approached, the researcher must be sure to carry across this information in a way that is understandable for them, making use of the translating ability of the DCA in situations where potential respondents do not understand English well. There may be a need to omit or rephrase portions of the above information that

is too complicated to understand up front, such as the terms "mixed-methods" or "quantitative", so that potential participants are not intimidated by the researcher and chose not to participate as a result.

Lastly, potential participants from both samples can be invited to participate in the study *without forcing or manipulating* their decision. The autonomy of each person must be respected according to the ethical principle of "Respect for persons" and given a choice whether or not they would like to participate, without using coercion or indue influence to force their decision. As such, people's decisions to participate must be respected and accepted, even *if* the researcher desperately requires responses – this maintains a high degree of ethicality.

After completing a survey response, the researcher intends to give each in-person respondent a incentive such as a closed sweet or snack to thank them for participating in the study – this is in no way a form of manipulation, but rather a "thank you" for their effort and time. Careful consideration must be made whether or not to include those with diminished autonomy in the sample, as attempting to convince these persons to participate will diminish the ethicality of the study. As for respondents with effective autonomy, a incentive is only given once a survey response is completed.

3.9.4.2 *Confidentiality of information*

3.9.4.2.1 Qualitative interviews

As mentioned in the informed consent procedure provided above, the last piece of information required in the informed consent process is informing participants how their information will be *used, processed and/or shared*, as well as the *measures* that will be taken to protect their information.

3.9.4.2.1.1 How information is used, processed and shared

Experts in the qualitative interviews should be informed that the information they provide is *used and processed* to better understand Gauteng's PT paradigm and how HCD measures are applied there, respectively, as well as the priorities that need to be addresses and the decisions that are advised. Furthermore, their views, guidance and experience in their specific fields are utilised to better inform the design of the quantitative surveys in the following research phase.

As such, all the qualitative interview data gathered is used as evidence and reinforcement for the study on which to base specific decisions and conclusions, given that it arises from experienced professionals working in Gauteng. The information provided will not be *shared* with any other person and is only used in this study. The only people reading their information will be those evaluating the study and those in the associated research community once the study is published. Any correspondence between the researcher and the participant will be kept confidential.

3.9.4.2.1.2 Measures taken to protect information

The identity of participants will be not disclosed, nor will they be asked to provide any personal information that can be used to identify them individually. All names will be replaced with a unique ID code in the study for reference purposes in order to keep participant names anonymous. The only personal data required is the job title and area of expertise of a participant, yet the names of the company and employer of the participant will not be disclosed. Furthermore, the study's report will not include any direct quotes or any information that could be associated with the participant.

The information provided by these experts was protected by simply replacing their names with an interview label, for instance *PT Expert A*. That way none of the private information provided relating to their opinions or associated companies can be traced back to these experts, thus protecting their reputation and respecting their privacy. Thus, even when scholars read the interview content, there will be no way of tracing it back to the professionals. In addition, experts were not asked any demographic questions such as their age, race or gender or any personal questions related to their own lives, as it is not important in this particular study and would risk the confidentiality of their information being breached.

Phone numbers will be used only to make initial contact with prospective participants, after which they will be completed erased from the researcher's phone and records. Each interview is conducted over Zoom™, recorded, transcribed and sent back to experts to give them the opportunity to remove comments or edit information as they see fit, as advised by Albertyn (2020). Email addresses were only be kept during the study to send back the interview transcriptions for editing, and only kept after transcriptions were returned to inform the participant of the study's results when it is completed, with the permission of the participant.

Email correspondence was conducted over one email thread per expert, which were all set to *Confidentiality* mode meaning no recipients may forward, copy, print or download the email thread. In addition, an expiration date of one month was set to ensure the expert is not personally associated with this study's research by the time it is submitted, giving the researcher ample time to conduct the interview, transcribe, share the transcription and receive feedback on the transcription before the email thread expires.

3.9.4.2.2 Quantitative surveys

3.9.4.2.2.1 How information is used, processed and shared

Information obtained from PT users is *used* to study the relationship between the incorporation of HCD measures into Gauteng PT design and the satisfaction of commuters with these services, as well as how this would improve the PT service quality offered to these users. As such, this information is *processed* to assess how PT users would react if the initial principles developed are incorporated into Gauteng PT design,

and whether these principles (the choice of which was informed by experts) would be capable of fulfilling their core needs as customers.

Commuters should be informed that their information is not *shared* with anybody else and is only used in this study, stored securely on the researcher's laptop and Google Drive™ only. Since their information is processed into pure numerical data and used statistically, it will not be possible to trace their information back to them. While individual survey sheets are not broadcasted in the study, they may be necessary as an addendum to the quantitative research. This will not be concern given the measures taken to protect this information.

3.9.4.2.2.2 Measures taken to protect information

All survey responses and the scanned COVID-19 contact register were be stored securely Google Drive™ and on the researcher's laptop, respectively, and are only shown when strictly necessary, i.e. as an addendum or during the evaluation of the final study. The only personal questions asked include the age (for statistical analysis), contact information (obtained with the permission of participants to inform them of the study's results) and the type of PT mode used. It is unnecessary to acquire any other information, as it would be irrelevant to this study. All other survey questions were designed to assess how commuters would respond if the initial principles were applied to the Gauteng PT context, meaning no other personal questions that could reveal a respondent's identity or breach the privacy of the information were asked.

The statistical processes followed are another measure of ensuring confidentiality, as all responses are analysed together and presented in the form of graph or statistical parameters – no one survey can be isolated and traced back to one respondent. Furthermore, the personal information filled in on the scanned COVID-19 contact register was not shown to anyone (unless strictly required by study reviewers) and will be deleted for good once the study is finished.

3.10 Data collection methodology

3.10.1 Introduction

In order to collect the data desired for each research phase, the most appropriate research methods and instruments must be chosen and their procedures understood in good detail. Therefore, this section explains which research methods and instruments are best suited to gather the data needed in each phase and selects methods with justification, also elaborating upon the nature of the methods from literature. Practical insights and guidance provided from the study's advisor is then discussed, and the data collection methodology relating to each research phase is then discussed.

3.10.2 Design and data collection procedures

3.10.2.1 *Phase 1 – Semi-structured, qualitative interviews*

Almeida, Queirós and Faria (2017) offer a procedure for carrying out qualitative interviews. Based on the insight obtained during research and the literature obtained on the matter, this procedure is updated to include a few intermediate steps, while some steps are rearranged to ensure a logical yet effective layout. The complete interview design guide is laid out as follows:

1. Clarify the objective/s of the interview:
   - What type of information is required?
2. Design two interview guides – one for PT experts and another for HCD experts
   - All questions should be designed based on collecting the insights required
   - include both broad and specific questions based on what insights are required
   - allow enough time and space for follow-up questions where necessary, while ensuring these questions are laid out evenly in the interview guide
   - estimate how long the interview is expected to take
   - a minimum of six interviews (three each) should be conducted; the number of interviews conducted are based on when data saturation is reached, and the desired insights are obtained
3. Ensure the interview guide is structured in such a way that the questions are complementary, build on one another and logically laid out:
   - Given this is a semi-structured interview in an exploratory study, the structure should be flexible and provide space for follow-up questions to be posed and discussed
4. Conduct a pilot interview to:
   - Test the applicability of questions
   - Incorporate new questions and insights, or remove existing questions if required

- Raise the researcher's confidence in conducting interviews

- Improve the researcher's interviewing skills

- Evaluate the timing of the interview, especially if follow-up questions are asked

- Restructured, rethink and refine the wording of questions as well as the interview structure

- Improve the likelihood of collecting rich, good quality data

5. Decide on a person to interview

6. Check that they meet the prescribed IC and EC

7. Contact this person and arrange a Zoom™ meeting

8. Conduct and record the interview at the prescribed time and place

9. Ask the first person to refer at least one person with the required criteria and expertise

10. Transcribe the interview

11. Analyse the data using qualitative content analysis techniques (investigated and presented in the data analysis section of this study)

3.10.2.2 *Phase 2 – Correlation-based quantitative survey*

Based on the insights provided by scholars, a step-by-step design procedure for constructing the second phase, quantitative surveys and collecting the data required is synthesised here. This updated procedure caters for the differences and discrepancies between the two research instruments chosen, successfully integratng these instruments into a single **quantitative correlation-based survey** that aligns with the MM research design chosen. The procedure offered below aims to simplify the quantitative design and data collection process by synthesising all information discussed into a step-by-step quantitative research design procedure that neutralises any inconsistencies that arise and lists considerations and guidance applicable to each step, as follows:

1. Define the survey objective/s (Bhat, 2020):

- What do you want to achieve by distributing surveys?

- What type of data do you wish to obtain?

- What do you plan to do with the results?

2. Describe the variables being investigated and characterise each by type (Bhat, 2020; UCLA, 2021):

- **Nominal/categorical** variables state only the name of the variable

- **Ordinal** variables include the variable name and order (i.e., relative level of importance)

- **Ratio** variables include the variable name, order and zero-value option (i.e., cases when the variable is not applicable/present)
- <u>Note</u>**:** the term *independent/dependent variable* cannot be used in the quantitative phase since it comprises of correlation research

3. Select the target audience who would provide information best suited to the objectives of the study and survey (Bhat, 2020)

4. Identify the type of quantitative survey questions (QSQs) to be used in the survey based on the target audience and objectives for the survey, as well as the research questions and objectives (Bhat, 2020):

- **Descriptive** questions help obtain information about a variable so it can be quantified, each one specific to a particular group of people. These questions begin with phrases like: "What is this…?", How much…?" or "What proportion/percentage…?"
- **Comparative** questions attempt to draw a relationship between two or more groups based on various dependent variables, for instance "What is the difference in/between…?"
- **Relationship** questions aim to establish any correlation, trend or cause-and-effect relationship among two or more variables by asking what relationship exists between dependent and independent variables in the study

5. Formulate the survey questions:

- Ensure that all questions steer clear of restriction of range problems (Price et. al., 2017)
- Ensure questions are designed in such a way that the responses best reflect the true emotions, views and behaviour of the respondent (Almeida, Queirós & Faria, 2017)
- All questions should be defined to meet the survey objective and obtain in-depth information and understanding of the research topic
- Keep all question short, simple and clear
- As a guide, start a survey with straightforward demographic questions and follow up with either closed-ended multiple choice questions (MCQs) or more qualitative open-ended questions
- Note that MCQs are simple to process yet are limited by the level of detail that can be obtained, while open-ended questions are more difficult to process but provide richer, more personal information (Bhat, 2020; Aziakpono, 2020)
- Include several open-ended questions, as they can offer valuable insights previously not considered

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6. Arrange these questions into the most optimal survey structure to collect the digital data desired (Bhat, 2020; Albertyn, 2020):

    - Order should be based on achieving the study and survey objectives

    - Position related, complementary questions alongside one another

    - Related questions can be preceded by a disqualifier question, meaning if the answer to the first question is "no" then the following questions do not need to be answered

7. Check that the flow of the survey questions is logical, effective and simple to follow

    - Evaluate how easy the questions are to read

    - Clarify any ambiguity present

    - Ensure target audience understands what information is required from them

8. Finalise the survey questions, structure and presentation (maximum of two pages)

9. Conduct a pilot study of around 10 responses with the digital survey. In this case, this pilot study could also be a probe to figure out an effective yet practical way of getting doubtful participants to get involved in the study.

10. Select locations for data collection in Gauteng where the most apt and relevant data can be collected to support the study's objectives (Almeida, Queirós & Faria, 2017):

    - Examples of in-person locations: taxi ranks, bus stops and train stations

    - Example of digital, online locations: social media (Facebook™; Instagram™), communication platforms (WhatsApp™; Signal™; Gmail™; Microsoft Outlook™) and online surveys (Google Forms™; SurveyMonkey™)

11. Collect data using the final correlation-based quantitative survey, ensuring enough surveys are completed as indicated by the research sampling section.

3.10.3 Practical insights and guidance

This section summarises the insights and guidance provided by the study's advisor to successfully consider, plan and execute each section of the study in the most simple and effective way. All insights were considered and only used if their application would serve the best interests of the study's objectives. The integration of these insights into the data collection design and procedure for each phase are discussed on subsequent sections.

3.10.3.1 *Phase 1 – Semi-structured, qualitative interviews*

Since the study aims to integrate aspects of HCD thinking with Gauteng PT design, both PT experts and HCD professionals should be interviewed. A minimum of two interviews and a maximum of five interviews were decided upon, but in order to fairly include both professions and the unique insights they hold, a total of six interviews should be conducted: three with PT experts and three with HCD experts. For this reason, it may be best to construct two unique interviews for each type of expert, since their knowledge is unique to their profession and would reflect the type of information gathered. In addition, it was decided that interviews would last one hour each so that respondents do not become fatigued or disinterested, potentially providing poor responses as a result.

A snowball sampling approach was suggested in addition to an expert sampling approach to recruit apt experts with the necessary criteria for interviews, allowing new interview candidates with an adequate level of experience and knowledge on the study topic to be recommended by the first respondent. In addition, it is more likely experts would prefer being recommended for an interview by someone that they know than being found impersonally online. This may enhance the level of comfort felt by those recommended and thus allow richer, more insightful information to be shared during the interviews, in turn suggesting a final interview recommendation. An initial recommendation for an interview candidate was offered by the study's advisor; this candidate would more than likely know someone with the required expertise and insight required in this study, since they may work in the same company or project.

Before constructing the questions asked in interviews, the researcher should first be aware of what type of information is required from these professionals: all questions should be developed around collecting these insights and understanding. Take note that, due to the flexible, explorative approach followed in this study, the interview structure should not be too fixed and allow new and related questions arising during the interview to be asked and discussed, as long as the interview keeps to its prescribed time and gathers the data required. At first, a pilot interview can be conducted to test the validity of the questions asked, raise the confidence the researcher has in his interview skills and assess where the interview can be enhanced to collect better quality data.

3.10.3.2 *Phase 2 – Quantitative surveys*

The form of the survey influences the answers one can obtain. Generally, the researcher should consider using several open-ended questions in the surveys, as these can offer quite valuable and insightful information that had not yet been considered. Before carrying out the official data collection, a pilot study of around 10 responses can be carried out to assess the effectiveness of the surveys and test whether the surveys are understandable and capable of collecting the type of data required. If the survey does not align with the goals of the study, the initial survey document can be refined to include new insights, change the way questions are phrased and create a revised document more capable of collect the desired information from the sample respondents.

In accordance with COVID-19 regulations, the researcher has decided not to use any material surfaces on which the virus can be transmitted during data collection to mitigate the risk of the virus being transmitted and protect the health of the researcher and respondent alike. As a means of collecting data without paper sheets or cardboard to reduce such risk, an idea has arisen to use a digital application on a tablet device in the field to collect and process data. Rubber gloves and a material face mask were used at all times while in the field to preserve the health of the researcher and obey pandemic regulations. There exist **three** data collection options for Phase 2t:

1. Each person can be presented with a unique digital form on the tablet that they complete in the presence of the researcher, after which the screen is sanitised for the next person.
2. Respondents can stand/sit at least 1.5 m from the researcher and point out which survey response most resonates with them without touching the screen.
3. Laminated survey sheets that can be completed with whiteboard markers. Pictures can then be taken of each survey response and both the sheets and markers sanitised thereafter.

In order to protect the physical safety of the researcher in this scenario, a DCA should be hired to keep watch over the researcher while data is being collected and alert the researcher if there is risk of criminal activity. The risk of collecting poor, incomplete survey responses must be reduced as far as possible, otherwise the researcher would need to recollect surveys and thus lose valuable time during data collection. One way of reducing this risk is contemplating how questions can be asked initially in an understandable way and simplified accordingly to ensure respondents stay interested and complete their surveys honestly. Another way is approaching respondents in a calm, respectful manner and making them feel at ease in the presence of the researcher, clearly stating the aim of the study and warmly inviting people to form part of the sample to have their voices heard.

The researcher should attempt to engage with those on the frontline of PT in South Africa, i.e., those who use PT services regularly and have fresh, reliable insights to share. This can be done by collecting data from

commuters waiting at or outside PT hubs such as taxi ranks, bus stops and train stations, as those recruited here would very likely align with the IC and EC specified. To encourage participation in the study, people can be incentivised by being entered into a lucky draw for a voucher or given an incentive thank them for completing a survey.

3.10.4 Phase 1 – Qualitative data collection

3.10.4.1 *Selecting the best methods and approaches*

According to Albertyn (2020), there are three main ways of collecting qualitative data: 1) listening to informants, 2) observing and 3) examining material. "Listening to informants" seems most fitting for qualitative interviews, and two main data collection methods are suggested: interviews or focus groups. Given that the researcher intends to ask local experts questions to gain insight about their PT system, interviews were selected as the most apt data collection method (Albertyn, 2020).

Interviews can be conducted either face-to-face, over the phone, over email or online over a meeting application like Zoom or Skype (Albertyn, 2020). A Zoom™ interview meeting can be employed, which can be recorded with the permission of the interviewees and transcribed. Furthermore, there are three types of qualitative interviews, namely structured, semi-structured and in-depth (or unstructured). The choice was made to employ a *semi-structured* interview in this study, as it allows a certain degree of flexibility so that the researcher can gain all the insights necessary to allow in-depth understanding of the topic to emerge. Moreover, this flexible discussion approach accounts for the exploratory nature of the study, allowing any new perspectives or insights on the topic that emerge during the interview to be discussed, as the researcher may not have initially been aware of an essential dimension of the topic. In-depth discussion and likely follow-up questions on topics of particular interest to the study are thus allowed.

3.10.4.2 *Description of the chosen methods*

Interviews are a more personal method of collecting narrative data than questionnaires as they hold space for an in-depth discussion on the research topic and allow the researcher to gather more exclusive information from the interviewee. By posing specifically designed questions, a researcher can investigate and gain deeper insight into the opinions, knowledge, preferences and experience of the interviewee that can be processed and utilised to answer unknown questions in a study. Even though the researcher may have control over which questions are asked, the reliability of the responses may be influenced by the personal perception of those being interviewed or the presence of the researcher themselves; this suggests more accurate insights may be obtained by non-physical interviews (Albertyn, 2020; Taylor, 2019).

3.10.4.3 *Guidelines for the data collection and analysis procedure*

The procedure for carrying out qualitative interviews begins by clarifying the aim of the interview, followed by determining who the researcher would like to interview and contacting them to arrange a meeting. Next, design the interview so that it includes broad, stimulating questions to gather the desired insights from the opportunity as well as follow-up or impromptu questions in case further clarity is needed. Finally, conduct the interview at the decided time and place, transcribe it and analyse the data using methods like coding (Taylor, 2019; Almeida, Queirós & Faria, 2017).

Albertyn (2020) offers a myriad of practical advice on conducting a successful qualitative interview to gather the most detailed, reliable information from the respondent. The focus of an interview should always be to gain as much depth and insight from the respondent and thus being a "container for their truth", so an interviewer should remain neutral and respectively curious, practise their listening skills and keep the tone conversational so that the respondent feels comfortable enough to share personal information. All questions should be asked so that respondents answer them from their level of experience rather than from speculation, keeping the language in the interview questions simple and unambiguous. Interviewers should send the respondent the interview guide prior to the interview so that they are aware which questions are being asked and which they cannot answer, ensuring they stay on script during the interview to avoid getting side-tracked (Albertyn, 2020).

The interview should be transcribed shortly after it is completed and the transcriptions sent to the respondent, giving them the opportunity to change any of their answers before a certain date prior to the information being processed. Once this is done, omit interesting but irrelevant information from the interview to condense the insights gathered into only the most relevant; this information can be included in another appropriate section like the recommendations or discussion. Using a qualitative coding process, valuable insights in the form of quotes (with the times indicated) are then grouped into well-known terms known as codes, which are further grouped into subthemes and then themes. Coding can be included in the addendum as a way of indicating the rigor a researcher invested into the study. Notably, the qualitative coding procedure was discussed and applied in the data analysis section of this study (Albertyn, 2020).

3.10.4.4 *Developing the interviews*

The qualitative interviews are now developed by following the recommended research instrument design procedure that was synthesised in section 3.10.2.1. This design process begins by considering the type of information required from this research phase to satisfy to the research aims and answer the research questions, providing a basis for the development of this research instrument and thus simplifying and optimising the process of creating this instrument.

3.10.4.4.1 Step 1 - Deriving interview objectives

A list of interview objectives is summarised based on the requirement stipulated in section 3.10.3.1 as well as the research aim, research questions and research objectives, while any new realisations or insights attained during the data collection process are also incorporated. A list of objectives are provided for each interview type (i.e. with PT or HCD experts) and listed in a logical, complementary order which suggests the order in which interview questions can be asked. Since HCD involves making human needs the centrepiece of design (Design Kit, 2021), the beginning point of each list aims to clarify and define the needs of commuters.

Objectives for PT expert interviews:

1. Clarify and define the key travel and personal needs of South African PT users (i.e. what needs do commuters want met in order to be satisfied with PT services?).

2. Assess and describe which measures have successfully been put into place to account for human needs, preferences and complaints in the design of South African PT services (i.e. which HCD elements are *currently* being implemented?).

3. Assess which commuter needs have *not* been successfully met in the design of South African PT services and what can be done to account for these.

4. Understand the role and importance of a commuter in the operational success of the South African PT system (i.e. what difference does it make in the system when commuters are fulfilling their roles and have their needs met? Will commuters with satisfied needs be capable of supporting or reforming our PT system, given their frustration with unreliable services?).

5. Enquire which aspects of South African PT design are, at this point, the highest priority to improve or optimise in order to enhance the operational success of PT services, as well as the potential of human-centric elements in offering this support.

6. Gather opinions (with justifications) on whether the incorporation of human-centric elements (e.g. safety, convenience, accessibility, etc.) into South African PT design would be *palatable* for commuters and capable of meeting their travel needs.

7. Gather practical advice on how the proposed HCPTD principles can be effectively applied and utilised by transport authorities and the transportation industry to improve the quality of PT provision.

8. Assess how current PT design, strategies and policies must be adapted to become more human-centric.

Objectives for HCD expert interviews:

1. Clarify and define the key travel needs and personal needs of South African customers. The accuracy and legitimacy of these needs can be tested and confirmed using the quantitative information provided from PT users in the second research phase.

2. Cultivate an understanding of how HCD measures are currently being applied in South Africa.

3. Understand how customers respond to HCD measures and which human-centric approaches are most effective in South Africa, given the unique preferences of its people and the country's unique conditions.

4. Assess which human-centric needs are *not* being met in South African customer services and what can be done to account for these.

5. Evaluate the extent to which a lack of HCD measures influences a customer's desirability or satisfaction with a customer service.

6. Gather opinions (with justifications) on whether the incorporation of HCD elements into South African PT design would be palatable for commuters and capable of meeting their travel needs.

7. Enquire and understand how transport authorities and operators of PT modes can become more accustomed to HCD, adopt it as an effective means of meeting customer needs and be willing to shift their behaviour and practises as a result.

8. Understand what is would take for South African national policies to be willing to incorporate more human-centric thinking into its national strategy, as well as how this policy-change process would actually be executed (given national policies must shift in order for more human-centric thinking to be adopted).

3.10.4.4.2 Steps 2 and 3 – Design and structure interview guides

The interview guides for both expert types are now developed based on the qualitative interview guidelines and the procedure developed. Once the necessary questions are designed, the questions are structured to ensure they follow a logical, complementary sequence, holding space and time for the discussion of possible follow-up questions in bullet-point form. The PT expert interview is shown in Addendum D, while the HCD interview is shown in Addendum E.

3.10.5 Phase 2 – Quantitative data collection

3.10.5.1 *Selecting the best methods and approaches*

There exist five main quantitative research methodologies, namely a correlation study, multivariate analysis, field experiments, simulation and surveys (Almeida, Queirós & Faria, 2017). After due consideration, it seems plausible that a combination between a **correlation study and quantitative surveys** are used to gather the desired data in the quantitative research phase of this study. Seeing as correlation studies use exploratory techniques to quantify the correlation between variables, the selection of this method aligns with the exploratory nature of SES MM strategy selected to guide the research. In addition, surveys would be an ideal way to accurately and directly obtain data from Gauteng commuters regarding how they perceive PT services, what their primary travel needs are and whether they believe the incorporation of HCD elements in PT design would satisfy these travel needs (Almeida, Queirós & Faria, 2017).

3.10.5.2 *Description of the chosen methods*

3.10.5.2.1 Quantitative surveys

Through a sequence of carefully designed questions, quantitative surveys obtain numerical data from a group of people regarding their opinions or perspectives on a particular phenomenon. These questions should be created and ordered in such a way that a respondent's unique behaviour, viewpoints and insights about the topic being investigated reflects clearly in their answers and is quantified accurately, such that the data obtained fairly represents the sample population and meets the researcher's survey objectives (Almeida, Queirós & Faria, 2017). Surveys are a primary source of data as the data is attained directly from respondents, known to be more difficult to collect than secondary data which is abundant and readily available (Aziakpono, 2020).

Surveys are among the most used quantitative research methods as both their cost and the time taken to develop them are lower than other methods, the data collected from the sample population also accurately representing the broader population and thus promoting generalisability. While the collection and analysis of data yielded from surveys can be easily implemented, it falls short of quantifying the varying emotional responses and behaviours of the sample. Moreover, the dependability of the data collected is strongly influenced by both the reliability of the respondents' answers and the sequence of questions asked in the survey, laid out in a fixed format which could limit the workability of the data. Nonetheless, the data collected is not influenced by the researcher's personal bias (Almeida, Queirós & Faria, 2017).

Therefore, to obtain the most reliable and accurate data, researchers should make their approach to respondents relaxed, conversational and inclusive, allowing them enough time to feel comfortable and think clearly about their answers. The layout of the questions in the survey also requires careful

consideration to ensure that the data gathered in dependable; a pilot study can be carried out prior to the official data collection as a trial run to test the effectiveness of the survey and allow any edits to be made based on the responses (Cooper & Schindler, 2001).

3.10.5.2.2 Correlation research

The main goal of correlation research is to determine whether a relationship exists between two or more variables, testing both the strength and direction of the correlation between two variables under examination (Bold, 2001; Almeida, Queirós & Faria, 2017; Price et al., 2017). Known to be a non-experimental approach, the variables in a correlation study are not altered, regardless of how or where they are estimated, as it would make it difficult and nearly impossible to accurately measure the natural degree of correlation between two variables. In fact, the term "independent variable" or "dependent variable" is not used in this type of research. A researcher merely witnesses how the variables behave in their natural habitat and attempts to quantify the relationship between them to inform the acceptance or rejection of the study's hypothesis (Price et al., 2017; Fleetwood, 2020; Almeida, Queirós & Faria, 2017).

While having greater external validity than experimental studies, correlation research often lacks both internal and external validity in the study's findings and the associated academic community, respectively, needing to trade these aspects off with one another (Almeida, Queirós & Faria, 2017; Price et al., 2017). Correlation studies do, however, have the capability of accumulating a vast variety of data from several target audiences simultaneously, greatly assisting in offering conclusive proof for an emerging theory (Almeida, Queirós & Faria, 2017; Price et al., 2017).

Once it is found that two variables are indeed related, a statistical strategy known as regression can be applied to test the correlation between these variables, thus utilised to test the dependability and legitimacy of values measured in the field (Price et al., 2017). However, the trends between variables in correlation research are known to be particularly dynamic and thus ever-changing; trends observed and quantified in the past may also change as time progresses (Fleetwood, 2020).

3.10.5.3 *Guidelines for the data collection and analysis procedure*

Guidelines for the collection and analysis of data in quantitative surveys and correlation research is presented in Addendum F.

3.10.5.4 *Synthesising and updating the quantitative research procedure*

Based on the guidelines offered to collect and analyse data in each method and the alterations to the strategies decided upon, this section blends these individual procedures into one main research design procedure. It should be noted that these methods are integrated by conducting correlation research within the format of a quantitative survey. The order of the steps in the research procedure were decided upon

based on both the original guidelines from literature and logic exercised by the researcher. The quantitative research procedure for Phase 2 of this MM study is as follows:

1. Define the objective of survey.
2. Describe the variables being investigated and characterise each by type.
3. Select the target audience who would provide information best suited to the objectives of the study and survey.
4. Identify the types of QSQs to be used, based on the target audience and objectives of survey, as well as research questions and objectives.
5. Formulate the survey questions. Ensure that all questions steer clear of restriction of range problems and are designed in such a way that the responses best reflect the true emotions and preferences of the respondent.
6. Arrange the questions into the most optimal survey structure to collect the data desired, based on the study and survey objectives.
7. Evaluate how easy the questions are to read, clarify any ambiguity present and ensure target audience understands what information is required from them.
8. Finalise the survey questions, structure and presentation.
9. Select locations for data collection where the most apt and relevant data can be collected to support the study's objectives.
10. Collect data using the final quantitative survey, ensuring enough surveys are completed as indicated in the research sampling section.
11. Summarise and tabulate the survey responses into computer software.
12. Select a sequential statistical method to analyse data.
13. Plot data on a scatterplot diagram and remain aware of any trends or patterns that arise.
14. Quantify the correlation by obtaining r from the statistical analysis.
15. Quantify the covariation.
16. Interpret findings and what they imply to the study, using *r* and the scatterplot form as a reference.

3.10.5.5 *Developing the surveys*

3.10.5.5.1 Where to from here?

A mixed-methods SES has been chosen for this study. This implies *qualitative* data is gathered and processed in Phase 1 (as was done in the six qualitative interviews), followed by collecting and analysing *quantitative* data in Phase 2 to reinforce and interpolate these initial findings. Therefore, numerical data is used to interpret narrative findings (Creswell, 2009). Furthermore, a basic MM report structure offered by Mertens (2003) was adapted to be applied in this study as follows:

1. gather, analyse and interpret *qualitative* data in Phase 1

2. conduct *quantitative* research in Phase 2 to support and strengthen the qualitative findings

3. presenting a *discussion and conclusion*, mentioning how the quantitative findings complemented and reinforced the initial qualitative results, as well as how this combination of approaches assisted in answering the research questions and resolving the research problem

This structure is supported by Terrell (2012) and Creswell (2009), stating that interpretation of the qualitative and quantitative findings in a MM SES study takes place to discuss how the numerical findings reinforced the initial narrative findings and what the implications of finding are to the study (Terrell, 2012; Creswell, 2009). Furthermore, narrative and numerical data sets from each research phase are only mixed in the *discussion and interpretation* section of the study once each data set has been interpreted separately and the key insights are applied in the subsequent phase (Terrell, 2012; Creswell, 2009).

3.10.5.5.2 Introduction

With the above in mind, it is clear that mixing of this study's qualitative and quantitative data only takes place in the *discussion and interpretation* section of the study **after** Phase 1's results are applied in Phase 2 *and* both datasets have been interpreted separately (Terrell, 2012; Creswell, 2009). Notably, quantitative surveys are conducted *after* analysing and interpreting qualitative data from the interviews (Mertens, 2003; Terrell, 2012; Creswell, 2009).

Given that the qualitative interview data was interpreted with reference to global literature in section 5.1.5.1, designing the quantitative surveys are the next step to address in this study. Note that since the study is sequential, the quantitative, correlation-based surveys in Phase 2 are designed to reinforce and add greater insight to the qualitative interview data collected in Phase 1, as well as what this data implies about the study (Terrell, 2012; Creswell, 2009).

According to Step 8 of the research approach stipulated in section 3.8 of the study's research methodology, the quantitative, correlation-based surveys are now designed to test the applicability of each initial principle developed, while being based on the survey objectives and scholarly guidance on how to effectively design quantitative surveys and correlation studies.

3.10.5.5.3 Survey design process

The procedure developed in section 3.10.5.4 was now applied to design the quantitative, correlation-based surveys.

3.10.5.5.3.1 Step 1 - Deriving the survey objectives

Given the sequential nature of this study, the primary objective of the quantitative surveys is to reinforce the findings of the qualitative interview data (Mertens, 2003; Terrell, 2012; Creswell, 2009). Survey

objectives should also correlate with Research Objective B, C and D, as Research Objective A was addressed during the qualitative interviews; Research Objective D can only be fully addressed after analysing the quantitative survey data in context of the qualitative data and mixing data in the discussion and Interpretation section of this study. Thus, the objectives for the quantitative surveys are as follows:

Survey Objective 1: Reinforce the findings of the qualitative interview data and evaluate its implications for this study.

Survey Objective 2: Evaluate the extent to which commuters' level of dissatisfaction with Gauteng PT services are related to a lack of HCD measures in PT provision.

Survey Objective 3: Test each of the initial principles with commuters to evaluate which principles are most capable of promoting elevated customer satisfaction, as well as improve the service quality and operational success of these services. Three to five HCPTD principles are fully developed based on survey results.

Survey Objective 4: Reinforce qualitative interview insights on how Gauteng transport authorities and service providers can adopt more human-centric thinking and practically utilise the HCPTD principles (developed later on) in Gauteng's local context.

3.10.5.5.3.2 Step 2 – Select and describe the variables

Only **categorical** variables were considered in the surveys. The two variables studied are:

1. *HCD measures in South African PT service provision* describe the efforts made by transport authorities to understand the needs and desires of commuters and, in turn, design PT services in order to meet those needs (Design Kit, 2021; DC Design, 2017; Norman & Draper, 1986; Rogers, Sharp & Preece, 2015).

2. *Commuter's dissatisfaction with PT services*

3.10.5.5.3.3 Step 3 – Select the target audience

The target audience for these surveys include private- and PT users in the GP who have made use of a PT services (either rail, MBTs or busses, as these are the primary forms of PT in South Africa (TDA, 2014; Walters, 2014) in the last three years, namely since the beginning of 2018. The target audience should be other the age of 18 years old and should not include those who have a vested interest in promoting a particular PT mode, thus carrying a clear potential bias in favour of one mode over the another.

3.10.5.5.3.4 Step 4 - Identify the type of survey questions

The surveys are designed to cater for all respondents with the IC and EC stipulated. The bulk of responses are required from commuters who use PT daily and have more recent, accurate insight to offer based on their recent PT experience – this may include less educated commuters. Thus, questions were simplified as

far as possible to reduce survey response times, so relationships between certain independent variables were not asked, and comparative questions were omitted.

A few **descriptive** questions were included so that commuters could estimate how often their needs, feedback and involvement was considered in Gauteng PT design. Additionally, because the surveys aim to study the correlation between the two survey variables above, **relationship** questions were mostly asked to evaluate a commuter's satisfaction with, or response to, a given statement or scenario.

3.10.5.5.3.5 Steps 5 – 8 – Compiling the survey

The final version (version 8) of the quantitative, correlation-based survey is presented in Addendum B. This survey was edited after three rounds of the study advisor's feedback, structuring the questions as indicated in Steps 6, 7 and 8 and formatting the survey document so that it fitted on two pages only. Arguably, the survey length would play a significant role in the willingness to complete a survey.

3.10.5.5.3.6 Step 9 – Pilot study

Ten survey responses were collected from apt participants with the intention of:

1. Clarifying what commuters understand by the term 'transport authorities'
2. Estimating the survey response time and whether it was satisfactory for the participant
3. Studying the effectiveness of survey questions, and whether they were clearly understood
4. Understand a commuter's level of comfort filling in a survey response during pandemic circumstances

Thus, once the final version of the survey was confirmed by the study's advisor and the REC, a pilot survey was compiled to test the above, and apply edits, prior to collecting data from commuters.

3.10.5.5.3.7 Step 10 – Select location for data collection

A strategy for survey data collection has been decided upon and developed. A description of the sites where digital and in-person survey data was collected is now provided.

3.10.5.5.3.7.1 In-person data collection locations

Prior to data collection, the researcher summarised a list of locations where each type of PT user (namely train, taxi or bus) could be found. These locations are shown in Addendum C. These sites comprised of taxi ranks, street corners where bus stops could be found and Gautrain™ metro stations. While it isn't necessary to go to these locations exactly, the researcher and DCA used these locations as a general guide in the event commuter could not be found.

In-person data collection took place over a period of 7 days in the GP. Due to the resource constraints of the researcher (including finances, transport and data collection team), the entire GP could not be

traversed, so an effort was made to cover the largest area possible with the time available. Table 3 summarises the date, number of responses and data collection locations for each data collection day. Figure 7 illustrates the number of responses obtained per area in Johannesburg, while Figure 8 illustrates geographically the areas the data collection team were able to reach during the seven-day data collection period. Notably, the route shown in Figure 8 was not followed exactly but illustrates a general idea of the order in which areas were visited during data collection.

It should be noted that while a total of 311 IP surveys were gathered, only 308 surveys were inputted into MS Excel™. The pictures of two responses (IP 294 and IP 298) could not be found, suggesting these responses were wiped off the laminated survey sheet before capturing them or they went missing when pictures were transferred. Notably, the informed consent forms for these responses were obtained. One more survey response could not be accounted for, likely due to the above stated reasons.

As is shown in Figure 7, only one response was collected in Greenside and Sandton, respectfully. The data collection team decided to collect data at PT hotspots in the Johannesburg area (such as the CBD, Braamfontein and Rosebank), as more commuters could be located and recruited with less effort. Greenside and Sandton were omitted from the data collection as it was assumed mostly upmarket people would be found there – these individuals most likely do not use PT often and thus would not resonate with the sample required. Nonetheless, a response was collected from each area without planning while data was being collected.

Table 3: Summary of responses and location for in-person data collection

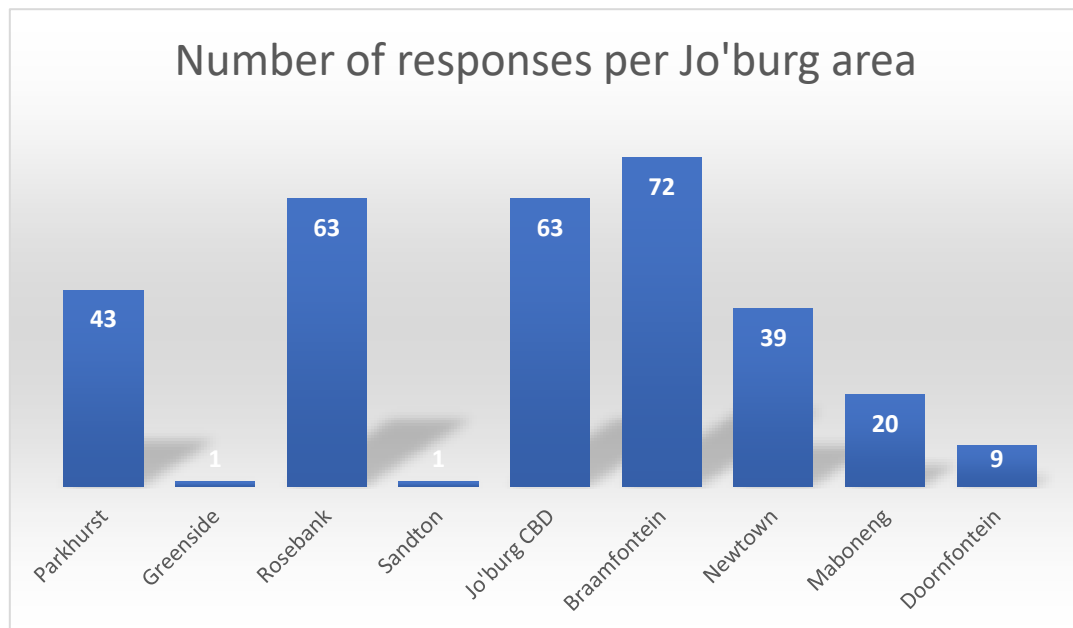| Data collection day (date)	Number of responses obtained	Areas where data was collected
Day 1 (30 September 2021)	33	Parkhurst Greenside Rosebank
Day 2 (4 October 2021)	40	Rosebank Parkhurst Sandton
Day 3 (8/9 October 2021)	34	Parkhurst
Day 4 (11 October 2021)	42	Johannesburg CBD: Ghandi Square Rissik Street Library
Day 5 (12 October 2021)	43	Braamfontein Jo'burg Theatre
Day 6 (13 October 2021)	46	Parkhurst Newtown Braamfontein
Day 7 (15 October 2021)	73	Newtown Maboneng Doornfontein Ghandi Square (CBD)
TOTAL	**311**	-

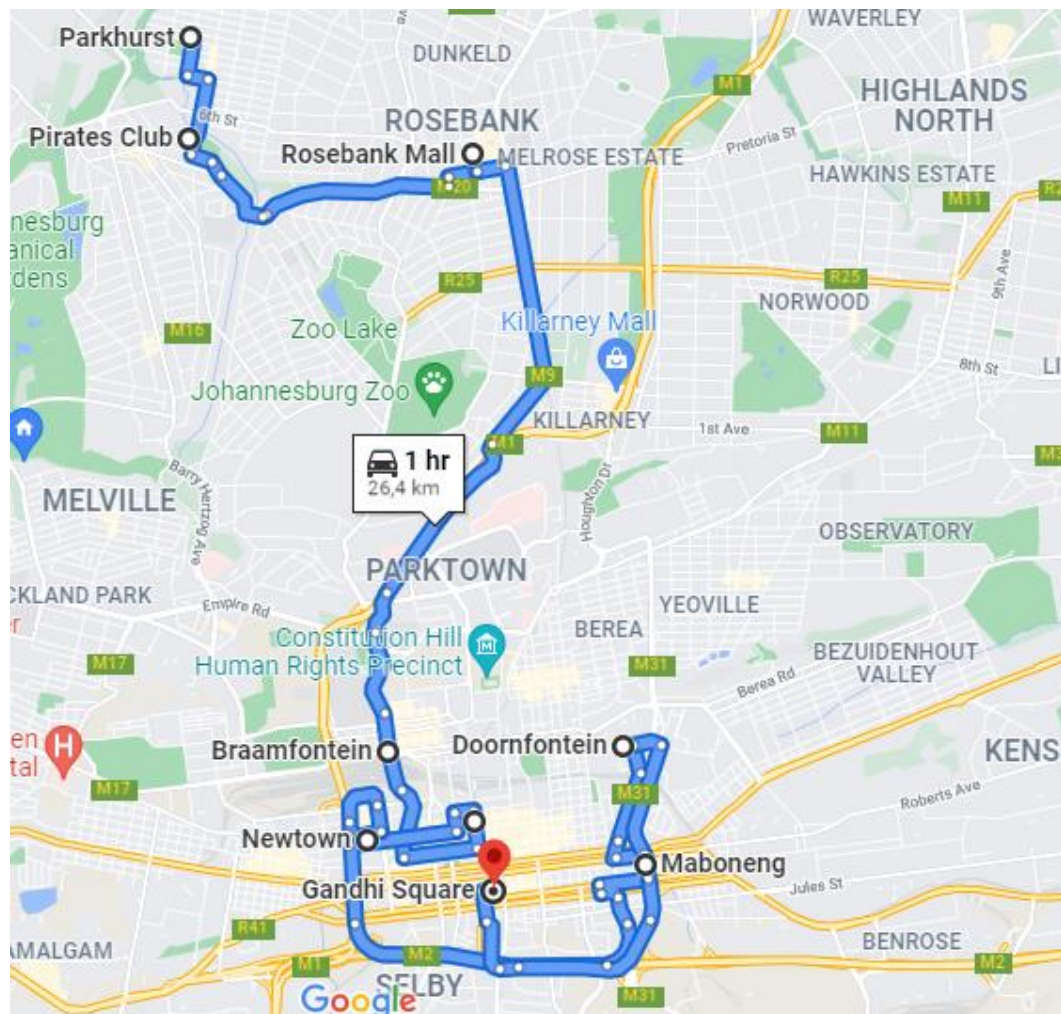*Figure 7: Number of in-person survey responses obtained per area in Johannesburg*

Figure 8: A geographical illustration of the data collection areas in Phase 2

3.10.5.5.3.7.2 Digital data collection locations

A recruitment message with a link to the online version of the survey was posted on Facebook™, Instagram™, Twitter™, WhatsApp™ and to some over Gmail™. The message was shared on social media paged associated with taxi, rail or bus PT services such as Gautrain™, Metrorail™, Metrobus™, Faraday Taxi Association™ and the Gauteng Department of Road and Transport, while several people were contacted directly over WhatsApp™ and invited to participate. Despite the extended effort put into contacting PT users and the R500 cash prize announced, a total of only **eight** digital surveys were obtained.

3.10.5.5.3.7.3 Quantitative sample split

Now that the minimum sample size has been determined, it is important to consider how this quantitative sample is split up so that it is representative of the Gauteng PT commuter as well as realistic for the researcher and data collection assistant. The simplest way to divide the sample up into fair proportions in context of this study is by using reliable, factual demographic data relating to PT modal split percentages. Given that the GHS 2018 is the most recent and reliable representation of South Africa's demographic statistics to date, it shall be used for this purpose.

Referring to Figure 6 on page 91, Table 4 summarises the modal split percentage for each PT mode, indicating how many respondents should be selected per PT mode from the total number of required responses. A total of minimum 300 survey responses is required to satisfy the LOC and MOE stipulated. However, it may not be possible to collect all of these responses in-person due to COVID-19 circumstances or the time available for data collection, implying a portion of the responses should be collected digitally, too. The proportion of in-person (IP) and digital (D) survey responses required are from now on presented in the form of **data collection scenarios** (DCSs), which were selected based on the exploratory nature of the study and what is plausible in terms of time and willingness during the second data collection period. A convenience sampling approach chosen for the second phase of research, so a proportion of IP responses was chosen to ensure it is realistically possible for just the researcher and DCA to collect.

The DCA assisted the researcher with the recruitment of participants, translation to other native South African languages (if needed), helping respondents understand and fill in survey questions, taking pictures of completed survey responses and sanitising laminated survey sheets and pens. With the help of the DCA in the field, the researcher was capable of collecting a great number of IP survey responses, although collecting 300 IP survey responses was considered daunting. Additionally, it can be argued that many PT users in Gauteng are captive to the system and thus have limited access to technology such as smartphones and laptops that can regularly access the Internet. This was the primary reason why in-person data must be collected during COVID-19, as these people carry the most accurate and reliable information due to

regularly using these services and cannot be omitted from the sample because they cannot be found online; these people are easily found at their respective PT hubs or waiting areas.

Thus, to make the collection of the minimum quantitative sample size more realistic but also flexible (given the exploratory, convenience quality of this phase), three DCSs are recommended, the first of which is the most desirable and the rest decreasing in desirability. Thus, if DCS 1 cannot be achieved, DCS 2 was made the aim, etc. Note that because a great deal of effort and finances are already being invested into IP data collection, the researcher desires that a great portion of **IP** responses are collected. These respondents can be accessed more simply than searching for them online and are more versed with existing PT services in Gauteng because they regularly use them, thus having more rich, reliable data to offer. The numerical distribution for each DCS is presented in Table 4:

- **DCS 1:** 20% D; 80% IP
- **DCS 2:** 30% D; 70% IP
- **DCS 3:** 40% D; 60% IP

Note A: the utilisation of any DCS is warranted, so long as the sample participants:

1. Meet the IC and EC specified
2. Follows the PT mode split (ensure fair representability)

Note B: It can be argued that those completing IP responses at PT hubs are generally more likely to be technologically- or financially captive versus those completing *digital* responses from their cell phones, laptops or computers. Therefore, to the furthest extent possible, the researcher should aim to collect as many IP responses as possible to ensure the data of more captive PT users are considered in the sample. This offers a balance of different PT users to provide a fair and balanced sample, and enables the accumulation of rich, accurate and helpful data from those who use PT services daily.

Table 4: The breakdown of survey responses required for each data collection scenario

PT mode	Modal split (%)	Calculation	Minimum number of responses required	DCS 1		DCS 2		DCS 3	
				D	IP	D	IP	D	IP
MBT	44.1	300 x (44.1/53.8) =	246	49	197	74	172	98	148
BRT	4.4	300 x (4.4/53.8) =	25	5	20	8	18	10	15
Train	5.3	300 x (5.3/53.8) =	29	6	23	9	20	12	17
TOTAL	53.8%	-	300	60	242	91	211	121	181

3.10.5.5.3.8 Selecting the best strategy

There exist two possible strategies for collecting in-person survey data from commuters, namely:

1. Completing responses on an electronic tablet and sanitising it after each response and
2. Printing the survey and laminating it, so that it can be sanitised after each response

In order to select the most effective and practical data collection strategy, Table 5 summarises the benefits and drawbacks of either strategy. This comparison clearly illustrates that using laminated surveys to collect survey data would be cheaper, safer (both health-wise and for the research team) and more efficient than using a tablet, given several responses can be collected at the same time. Thus, data can be collected more swiftly using laminated pages than on a tablet, while the process is simpler than having to design a survey that can be filled in on a tablet and storing all survey responses on it. Thus, in-person survey data was collected using laminated survey sheets.

Table 5: Comparison between quantitative data collection strategies

Strategy 1: Electronic tablet		Strategy 2: Laminated surveys	
Benefits	**Drawbacks**	**Benefits**	**Drawbacks**
Survey responses can be saved onto the tablet immediately after each response.	Only one response can be completed at a time, meaning data collection will take a long time.	Several responses equal to the number of laminated surveys can be completed at a time.	The cost of laminating five surveys (around 10 pages).
Electronic informed consent forms can be completed and saved on the tablet after each response.	There exists the risk that the tablet is stolen or damaged while in public.	A greatly reduced cost of laminating pages versus having to buy data nearly every day to keep the tablet online.	When taking pictures of a survey response, there exists a risk that a cell phone could be stolen.
The tablet's screen can be sanitised after each response is recorded.	The cost of data to stay online will be significant.	The researcher already owns whiteboard markers which can be used by participants when filling in a survey response.	
Data can be collected more simply by touching the screen and writing on it, instead of typing.	The tablet's battery may die even when fully charged at the start of the day.	Markers can be sanitised after each survey response and placed in a "Sanitised" jar to be used later.	
	Participants need to be close to the researcher to read the survey and provide a response, without touching the screen or keeping the tablet with them while a response is recorded - this would increase the risk of virus transmission.	Participants can complete a survey response at a distance from the researcher.	

		Laminated surveys can be sanitised after each response and reused.	

3.10.5.5.3.9 Defining the strategy

In order to mitigate the risk of virus transmission during the in-person data collection of this second phase of research, the researcher commits to the following step-by-step survey data collection strategy:

1. When in public, approach prospective participants who are isolated, instead of those who are in a group. This limits the amount of people in the same space.
2. Ensure the researcher and DCA are wearing a cloth facemask and rubber gloves when in public.
3. Ensure prospective participants are wearing a facemask. If they do not own one, give them one.
4. Maintain a 1.5 m social distancing gap while providing people with study information.
5. Ask participants to fill in the COVID-19 contact register (printed) with a sanitised whiteboard marker, informing them that:
   - Their personal information will not be shared with anyone and destroyed when the study is complete
   - The marker and sheet have been sanitised before them.
6. Ask participants to sign the informed consent form (printed) before collecting data. The form requires their signature, the date, the current location and that the relevant boxes giving consent are ticked.
7. Sanitise the laminated survey sheet.
8. If participants agree to participant, ask them to fill in the sheet with the same marker, standing at least 1.5 m away in the event they have any questions.
9. Once a response is captured, ask the participant to place their marker it in a jar labelled "Unsanitised".
10. The DCA will take pictures of the survey response with their cell phone, in a safe and enclosed location to ensure their safety.
11. The DCA will sanitise the unsanitised markers as well as the laminated survey sheet, placing the sanitised markers in a jar labelled "Sanitised".
12. Finally, give the participant a sanitised gift incentive such as a pen, cap or sweet, ensuring it was not opened or touched thereafter.

Chapter 4 Results and Analysis

4.1 Phase 1 – Qualitative interviews

4.1.1 Introduction

Three interviews were conducted with PT- and HCD experts, respectively, summing to a total of six one-hour long interviews – more interviews could be conducted if greater insight or understanding was required. The researcher found that in insight provided in the six qualitative interviews conducted was sufficiently rich, detailed and relevant, so no more interviews were conducted.

4.1.2 Background and guidance for analysis

The following guidance on analysing qualitative interview content is offered by Albertyn (2020):

➢ After receiving the edited transcriptions, remove interesting but irrelevant information and deposit it into a separate document. This ensures only the most relevant insights are collected and condensed in the transcription, while the excess interesting information in the other document can be utilised in the discussion or recommendation sections.

➢ Qualitative thematic analysis can be executed as follows:

1. Group valuable insights (in the form of quotes) into well-known terms known as codes
2. Group codes into subthemes
3. Group subthemes into themes

➢ Include the coding process into an addendum to indicate the degree of rigor offered by the research

The intention in Phase 1 is thus too follow a *qualitative thematic data analysis*, suggested for qualitative research where a researcher wants to investigate peoples' beliefs about a specific topic and assess their knowledge and understanding thereof from the interviewee's experience (Caulfield, 2020). According to Caulfield (2020), the thematic data analysis process consists of six main steps, namely:

➢ becoming *familiar* with the narrative data, often through transcribing interviews

➢ *coding*, where segments of the text are highlighted, and appropriate labels or codes are assigned

➢ *developing themes*, where related codes are grouped into a list of themes

➢ *scanning over the themes* with reference to the data to evaluate whether any are missing, or whether existing themes should be split or combined together to be clearer and more effective

➢ *"Defining and naming themes"*, specifying exactly what each theme represents and providing simple, clear names

➢ *"Writing up" the themes* to present the analysis of the narrative dataset, including an introduction, methodology, results and conclusion

Linking with the guidance provided by Albertyn (2020), the researcher thus intends to group valuable insights emerging from the interviews (i.e., codes) into a list of subthemes and, consequently, themes for each type of expert, i.e., HCD and PT experts. The resulting themes are then used as a foundation to design and construct the quantitative correlation-based surveys in the second research phase, while also utilising the objectives specified for these surveys. Note that additional research will be conducted and synthesised once the interview data has been collected to clarify and better inform the data analysis process.

4.1.3 The qualitative thematic data analysis procedure

The procedure followed in the qualitative data thematic analysis of this research phase is discussed below and is illustrated in Addendum G.

4.1.3.1 *Step 1 – Insight extraction*

Initially, valuable interviewee responses were condensed into succinct, case-specific insights by paraphrasing these responses and tying together related comments into unique insights. A definition for an insight is provided from the first HCD expert (HCDE1) interviewed below.

HCDE1:I11 [Human-centric design Expert 1: Insight 11]

An insight is a new or different perspective on something we'd already known that results in an improvement in action and provides an opportunity for competitiveness that we didn't see before. It also changes the way you approach something.

As seen above in bold, each expert was assigned a unique interviewee ID so reference could be made to them without breaching their confidentiality, forming part of the unique code assigned to each one of their insights. An example of this insight extraction process from HCD Interview 1 is shown in Figure 9 below, where the comment of interest is highlighted on the left-hand side and an appropriate insight is provided on the right-hand side.

Figure 9: An example of insight extraction from the first HCD interview

4.1.3.2 *Step 2 – Grouping insights into emerging themes*

Once all insights were extracted from the six interviews, the insights were grouped into a single document and sorted into a list of emerging themes (ETs) that had emerged from the interviews. ETs were defined as umbrella themes for topics interviewees had regularly made reference to, allowing related insights to be grouped together for further discussion. Some ETs were relevant to the study in addition to interesting yet unrelated information provided by interviewees, allowing such related insights to be considered together. A total of 27 ETs were defined based on the six qualitative interviews conducted and summarised in Table 6 below.

Table 6: List of emerging themes (ETs) extracted from qualitative interviews

ET code	Subtheme definition
ET1	Lack of empathy in public sector and upper class due to competitive systems-centred design
ET2	The importance of proper consultation and negotiation with all relevant stakeholders
ET3	The troubling taxi industry - lack of regulation and enforcement
ET4	HCD definitions and insights
ET5	Successful application and consequential benefits of HCD
ET6	Reasons for rare utilisation of human-centric approaches in South Africa
ET7	The relationship between perceived value and the sustainability of PT
ET8	Common societal misconceptions of MBTs
ET9	Lip service from the government - insincere public consultation in the design process
ET10	Violence and deception in the MBT industry
ET11	Recommendations, insights and priorities for South African PT development
ET12	PT network integration - benefits and insights
ET13	The power of the people - the importance of municipal worker organisations
ET14	Inconsistencies in policy provision, the fragmented transport service environment and political will
ET15	Cases of successful HCD utilisation
ET16	Incorporating human-centric approaches into South African PT
ET17	Systems-centred design: its downfalls, benefits and proposed evolution
ET18	Attracting commuters to South African PT through elevated customer satisfaction - key needs and other recommendations
ET19	Harnessing innovation in the PT sector and why it is lacking
ET20	Practical empathy in PT design

ET21	Citizen inclusion, contribution and roles in service provision
ET22	Shifting cultural beliefs and attitudes towards PT in order to improve patronage
ET23	The current study's contribution to South African PT development
ET24	The relationship between HCD and the current mobility-trend focus in South Africa
ET25	Interviewee comments on the proposed study
ET26	The stagnancy, rigidity and inadequacies of South African PT
ET27	Interesting but irrelevant information

4.1.3.3 *Step 3 – Grouping emerging themes into main qualitative interview themes*

In the next step, most of the above ETs were sorted into four main qualitative interview themes. Most ETs were found to be related or complementary when considering their topics and the insights associated with them, so a decision was made to group these ETs together so that their topics could be discussed in context of their main theme. All but three ETs (21, 23, and 25) were sorted into the four qualitative interview themes, as shown in Table 7.

Considering the ETs grouped under each qualitative interview theme, related or complementary ETs (highlighted in the same colour) were grouped into a defined ST. Some ETs were *already* context-specific and were discussed separately, thus directly renamed into STs as shown by the bold text. After ETs were sorted into their relevant ST, a tally of each ST's insight frequency was done to determine how many references were made to that particular ST in the interviews, and the qualitative interview themes were numbered based on the *frequency of insights* grouped under theme, such that themes (with their relevant STs) could be discussed in order of importance indicated by interviewee responses. The insight frequency analysis done for each qualitative interview theme is shown in Table 8.

Importantly, **not all insights were specific to only one ST or theme**, so a decision was made to copy across insights from one ST that were relevant to another ST. The insights sorted under each ST were counted and tallied up for each qualitative interview theme, as shown in Table 8. Given the number of counted insights in each theme, the themes were ordered as indicated. While only 192 insights were grouped into the four themes (with 12 insights pertaining to ETs, 21, 23 and 25), more than 192 insights were considered in Table 8 as some insights were duplicated – 213 insights were considered in the four qualitative interview themes. Notably, STs placed or created under a specific theme were also numbered in a logical order such that one ST implies another and tells a coherent story. The same thinking applied to the ETs sorted into a specific ST, allowing a rough sequence of discussion to be outlined. Based on the insight frequency analysis in Table 8, the ordered qualitative interview themes with their associated, ordered STs and ETs are presented in Table 9.

Table 7: Grouping emerging themes into appropriate qualitative interview themes

Theme number	Theme definition	Associated emerging themes
?	Emerging solutions to key PT problems	ET5: Successful application and consequential benefits of HCD ET11: Recommendations, insights and priorities for South African PT development ET12: PT network integration - benefits and insights ET14: Inconsistencies in policy provision, the fragmented transport service environment and political will ET15: Cases of successful HCD utilisation ET16: Incorporating human-centric approaches into South African PT ET18: Attracting commuters to South African PT through elevated customer satisfaction - key needs and other recommendations ET19: Harnessing innovation in the PT sector and why it is lacking ET22: Shifting cultural beliefs and attitudes towards PT in order to improve patronage ET26: The stagnancy, rigidity and inadequacies of South African PT
?	Transitioning from systems-centred- to human-centred design	ET1: Lack of empathy in public sector and upper class due to competitive systems-centred design ET4: HCD definitions and insights ET6: Reasons for rare utilisation of human-centric approaches in South Africa **ET7: The relationship between perceived value and the sustainability of PT**

		ET17: Systems-centred design: its downfalls, benefits and proposed evolution ET20: Practical empathy in PT design ET24: The relationship between HCD and the current mobility-trend focus in South Africa
?	Inadequate stakeholder consultation in transport service provision	ET2: The importance of proper consultation and negotiation with all relevant stakeholders ET9: Lip service from the government - insincere public consultation in the design process ET13: The power of the people - the importance of municipal worker organisations ET21: Citizen inclusion, contribution and roles in service provision
?	MBT domination in South African PT	ET3: The troubling taxi industry - lack of regulation and enforcement ET8: Common societal misconceptions of MBTs **ET10: Violence and deception in the MBT industry**

Table 8: Insight frequency analysis to determine order of theme discussion

Theme number	Definition	Number of insights	% insights
1	Emerging solutions to key PT problems	104	47.9
2	Inadequate stakeholder consultation in transport service provision	47	21.7
3	Transitioning from systems-centred- to human-centred design	45	20.7
4	MBT domination in South African PT	21	9.7
SUM		213	100

Table 9: Qualitative interview themes and their associated STs and ETs

Theme number	Theme definition	STs and associated ETs
1	Emerging solutions to key PT problems	**ST1: Governmental issues in transport provision** 1. ET26: The stagnancy, rigidity and inadequacies of South African PT 2. ET14: Inconsistencies in policy provision, the fragmented transport service environment and political will **ST2: Means of attracting commuters to PT** 1. ET22: Shifting cultural beliefs and attitudes towards PT in order to improve patronage 2. ET18: Attracting commuters to South African PT through elevated customer satisfaction - key needs and other recommendations 3. ET19: Harnessing innovation in the PT sector and why it is lacking

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		ST3: Expert recommendations for PT development and their associated benefits 1. ET11: Recommendations, insights and priorities for South African PT development 2. ET12: PT network integration - benefits and insights **ST4: The role of HCD in South African PT development** 1. ET5: Successful application and consequential benefits of HCD + ET15: Cases of successful HCD utilisation 2. ET16: Incorporating human-centric approaches into South African PT
2	Inadequate stakeholder consultation in transport service provision	**ST5: Poor public consultation in transport service provision** 1. ET9: Lip service from the government - insincere public consultation in the design process 2. ET13: The power of the people - the importance of municipal worker organisations **ST6: Incorporating relevant stakeholders in the PT design process** 1. ET21: Citizen inclusion, contribution and roles in service provision 2. ET2: The importance of proper consultation and negotiation with all relevant stakeholders
3	Transitioning from systems-centred- to human-centred design	**ST7: Systems-centred design: its downfalls, benefits and proposed evolution**

		ST8: The relationship between perceived value and the sustainability of PT
		
		ST9: A comparison between HCD and mobility-related services
		  1. ET4: HCD definitions and insights
		  2. ET24: The relationship between HCD and the current mobility-trend focus in South Africa
		
		ST10: Why a lack of HCD utilisation in South Africa?
		  1. ET1: Lack of empathy in public sector and upper class due to competitive systems-centred design +
		    ET20: Practical empathy in PT design
		  2. ET6: Reasons for rare utilisation of human-centric approaches in South Africa

4	MBT domination in South African PT	**ST11: Poor regulation and enforcement in the taxi industry**
		  1. ET3: The troubling taxi industry - lack of regulation and enforcement
		  2. ET8: Common societal misconceptions of MBTs
		ST12: Violence and deception in the MBT industry

4.1.4 Discussion of interview results

The contents of the interviews are now reported on based on the structure provided in Table 9. Note that ETs are ordered under STs as well to clarify the order of discussion but were not rigidly discussed in that order. While all insights have been sorted into each of the 12 STs, it should be noted that some insights make reference to other themes, STs or discussions within STs. As such, even if an insight has been assigned to a theme or ST, its utilisation is not limited to that theme or ST alone. Note that all statements were supported by the insight they originated from in brackets, for example: (PTE1:I7).

4.1.4.1 *Theme 1: Emerging solutions to key PT problems*

The first qualitative theme of this research phase discusses how current PT problems in South Africa can be addressed, by synthesising a myriad of solutions offered from experts. It is interesting to note that nearly **half** of all the insights gained in this research phase (47.9% - see Table 7) were placed under this theme, strongly indicating that experts are both aware of the problems South African PT faces as well as solutions to address them. Additionally, this theme includes over **double** the amount of insights placed under Theme 2 (21.7%), showing that experts prioritise understanding existing transport issues and finding effective ways to develop South African PT to overcome them.

4.1.4.1.1 Subtheme 1: Governmental issues in transport provision

Phase 1 research found that the South African government (including transport authorities like the DoT) play a major role in the problems its transport system faces, both through a lack of leadership and system-centred, politically driven leadership.

4.1.4.1.1.1 Existing issues in South African transport services

Both PTE1 and PTE3 believe that safety and security are serious problems in South African PT. These problems are believed to be escalating in certain transport services due to an inability to address them, resulting in the degradation of services within those transport categories (PTE1:I18). PTE3 believes passenger safety on modes and at transport hubs is Gauteng's highest transportation priority, followed by cost-effective transport services that fairly translate to the service and travel times offered. The reason these travel times remain high is due to route congestion (PTE3:I26).

Decreasing the number of transfers between a commuter's origin and destination should also be prioritised along with the provision of integrated ticketing systems that cater for workers who have more than one place of employment. Proper information systems providing accurate, real-time information on routes, ticket fares and PT vehicle locations should also be a priority (PTE3:I26). Commuter forums that are currently in place accommodate interactions between commuters, operators and the government to resolve transport issues. Unfortunately, these forums mostly address day-to-day operational matters

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relating to bus breakdowns and late busses, thus "not actually dealing with what's required on a strategic level, what's required from the commuter" in terms of travel time and number of transfers (PTE3:I4).

Another issue that should be considered is unregulated, oversized transport operators. PTE3 claims the DoT has "allowed certain operators to become too big", meaning the infrastructure owned by these service providers cannot be unbundled to accommodate for network integration because these facilities "have become pivotal to the success for PT service provision." Even if a tender was assigned to a new operator to promote such integration, the DoT desperately requires the operation of oversized service providers for South African transport to be successful. In addition, any new operators also do not have the infrastructure or facilities current operators do (PTE2:I13).

Arguably, oversized service providers have simply found a gap present in South African transport provision, thus profiting from the DoT's poor transport provision capabilities and inability to integrate the network. Existing BRT services were created from a political will to exhibit South Africa's transport development, yet these services are owned by ex-MBT and ex-bus operators affected by the provision of this service, being profit-driven and not caring what their customers think or need. If the provision of BRT services was an attempt to positively transform South African PT, are authorities *actually* improving these services? (PTE2:I32)

4.1.4.1.1.2 The stagnancy and rigidity of South Africa's transport system

Five of the total 204 insights extracted from the interviews related to the extreme rigidity, stagnancy and fragmented development of South African PT. PTE3 believes none of the key commuter needs in South Africa have been successfully accounted for, stating that the transport system is the same as it was in 1984 when they started working, with the same number of routes and busses in operation (PTE3:I9). Furthermore, operation schedules provided by the DoT have not changed since 2004, allowing no accommodation or provision for changes, growth and commuter requirements (PTE3:I1). While inputs from commuters during the transport design process is a requirement, PTE3 says "passengers just never got an input on the product" – "it's always prescribed" (PTE3:I9) – stating that commuters play a limited and rigid role in the operational success of the South African PT system (PTE3:I1).

PTE3 believes the inability of South African transport authorities to evolve their PT system is "definitely" limiting the system's potential. Great deals of funds are being wasted due to the duplication of services and the incorrect transport mode being selected on particular travel routes (PTE3:I10), in turn causing the PT system to remain exactly the same because of the subsided systems currently in operation (PTE3:I1). While believing the design thinking behind South African PT service development is flawed and in need of positive reform, HCDE3 believes the situation is "really complicated" since so many elements (from policy issues to

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practical elements) need to be reformed (HCDE3:I16). PTE3 believes there is a great deal "of room for improvement and growth in the [transport] industry" (PTE3:I10).

In support of this, HCDE1 advises that authorities take a step back from the issue at hand and evaluate what success would look like from a bigger picture, working towards that ideal scenario instead of "cobbling away" from where they currently are to get there (HCDE1I39). This view is supported by PTE2, who believes "we are *patching* together a transport system" in South Africa "because we think that's how it *must* be patched together, but that's not how the public or community or the civil society *wants* it." (PTE2:I33) These two insights emphasise the rigid, limited role of the South African commuter in the transport design process and the fragmented development of South Africa's PT system.

4.1.4.1.1.3 Poor policy implementation

Five interview insights relate to poor (or a lack of) policy implementation in South African PT. PTE3 states that transportation is seen as a high-risk career primarily because there are too many uncertainties, a lack of "control in the transport industry at this stage" and an incapability to implement transport policies (PTE3:I15). This view is supported by HCDE2, stating that municipalities who, through effective negotiations, create an agreement and agree to implement it very often fail to carry out on what they had agreed on. This leads to additional resources such as consultants being used unnecessarily (HCDE2:I26), providing another strong reason for wasted funds in the PT industry as mentioned in the section above.

PTE2 says that South Africa is "*overburden* with policies but no *implementation*." A good example of this is the Integrated PT Network Plans (IPTNPs) that must be implemented by every province in South Africa. While these plans are mandatory, government departments have been unable to them (PTE2:I11). In support of this view, PTE3 states that while transport authorities have got "very nice plans", these plans are not being implemented due to a lack of capacity where that work must be done, believing this is where authorities lack to a great extent (PTE3:I12). When asked what prevents authorities from implementing agreed-upon plans and policies in the transport sector, PTE3 asserted that a lack of knowledge and experience is the cause (PTE3:I14), while PTE2 declared that funding is the main reason (PTE2:I12). The latter insight is directly related to the observation that funds are being wasted in the transport sector.

PTE2 emphasises the need to "capacitate and skill the government departments to be able to implement those [IPTNP] plans". It is believed that only then will operators "get certainty in terms of the PT policy" and get investment and buy-in from operators who want to be part of the proposed IPTNP (PTE2:I11).

4.1.4.1.1.4 The role of political will in transportation development

Overall, five insights made reference to the political and authoritative aspect of transport development in South Africa, where the term "political will" appeared three times. This illustrates awareness on the part

of experts that political will and leadership is central to developing South Africa's PT system. In support of this, both PTE2 and PTE3 claim that political will is the primary means of addressing unmet commuter needs in South Africa (PTE2:I8), being one of the main reasons for limited growth and development of South Africa's PT system (PTE3:I12).

PTE2 explains that as government changes occur every four- or ten years, "there's no consistency with regards to policy, implementation" or "*meeting* the needs of people". This insight ties into the section above on poor policy implementation, as inconsistencies in policy implementation creates a fragmented environment for transport provision (PTE2:I8). In conjunction with this, PTE3 pointed out that with "the upcoming local elections, you will have a stoppage of [PT] services for certain individuals to further their political aims" so that leaders are better recognised. Furthermore, PTE3 states that "commuter operation is a political problem": the "commuter is politically very sensitive and abused by individuals in communities" (PTE3:I5). Given these expert views, is the South African government *really* prioritising the development of its PT system to serve the people, or is PT only developed to serve their own political agendas?

HCDE2 supports the above view, explaining that municipalities applying public consultation effectively "don't always last that long" due to the ulterior motives, differing priorities and selfish political agendas of those who come into power at that time. Effective and progressive policy processes are often killed off as a result, so sustaining excellent consultation procedures "often depend on the good will of somebody that happens to be in charge at the time." (HCDE2:I24). HCDE2 believes what is required to apply more bottom-up community consultation is "somebody who comes in with a different interest, who would then prioritise that different interest" – this requires a great deal of effort and focus to successfully and consistently employ this (HCDE2:I28). Primary reasons for such fragmented policy provision are a lack of consistent, statutory examples of proper public consultation and municipalities often not being institutionalised (HCDE2:I24).

In conclusion, HCDE2 believes the "mindset changes of people in power" is a key issue that is going to come to light (HCDE2:I40). As can be seen from the expert insights presented above, it seems the mindset of transportation leaders in South Africa are more focussed on their own political agendas and goals than providing a good service for their commuters. HCDE1 supports this view, claiming that service providers are going about design thinking in the wrong way and focussing only on achieving organisation goals, instead of asking how the design process *itself* can be optimised (HCDE1:I23).

4.1.4.1.1.5 A lack of HCD measures in South African transport

HCDE1 believes the poor quality and reliability of South Africa's infrastructure is a result of a lack of human-centric service delivery (HCDE1:I6). This claim is supported by both PTE2 and HCDE2, who say "there's never

been an element of [the] human-centric – it has been scientific, mathematical and economical, and that end result package is what drives PT" (PTE2:I27) and that the design thinking behind South Africa's PT service development is flawed "because of a lack of involvement of the human factor", stating that "that's what it needs." (HCDE2:I41)

Furthermore, PTE2 says the scientific, mathematical and economical package that is currently being used to design South African PT services is "not by any manner or any stretch" addressing unmet commuter needs. All that is being provided is a transport service that government can afford, mainly because the government needs to subsidise lower-income commuters (based on their demographics) so that they can afford to use transport services (PTE2:I28). Thus, HCDE1 believes the gap in South Africa's transport service delivery is created by service providers assuming they are meeting all their customer's needs, and that their product or service is working well – assuming that they *know* what their customer's problems are (HCDE1:I21).

4.1.4.1.2 Subtheme 2: Means of attracting commuters to PT

The results from the qualitative research interview indicate that the fulfilment of commuters' key needs is the primary way of attracting customers to South African PT. In addition to this, discovering and harnessing innovation in the PT sector is also crucially important for South African PT to develop, flourish and be accepted by commuters.

4.1.4.1.2.1 The key travel needs and personal needs of South African commuters

Safety and security were emphasised by all three PT experts, as well as HCDE3 (HCDE3:I17), as one of the most important commuter needs, both at ranks and in PT vehicles (PTE3:I7) so that commuters can access transport services safely (PTE2:I4). It is noted that a large portion of middle-class people "will not use PT because of safety" (PTE1:I5). It seems that the **affordability** of PT services is of nearly equal importance, as it was mentioned by all three PT experts. PTE1 says that "affordability is quite a huge factor in PT, because PT actually transports the majority of workers" (PTE1:I4), while PTE3 says that affordability is commuters' "number 1" need – commuters "will sacrifice a lot of luxury, but the bus should be affordable: that's very important for the passengers" (PTE3:I7). These views are reinforced by PTE2, claiming that if a transport service is "affordable and safe, then people would *want* to use it" (PTE2:I23).

Following this, PTE1 (PTE1:I4), PTE2 and HCDE3 (HCDE3:I17) state that the **reliability and punctuality** of transport services are important, especially to transport service providers as a reliable service develops into a sustainable service (PTE2:I23). This need strongly relates to an omission of vehicle breakdowns (PTE3:I7), which commuters require as it improves the reliability of the service. Considering the paragraph above, PTE2 believes "access to safe, affordable and reliable transport" is currently the highest priority in South Africa's PT provision (PTE2:I23). This introduces the next key commuter need – **accessibility**. This relates

strongly to insights indicated above, as commuters require *access* to "safe, affordable and reliable transport" (PTE2:I23) and require "safe facilities to be able to access that." (PTE2:I4) PTE2 explains that "if you're giving people access, that means you've thought about and designed that there's access for everybody" (PTE2:I23), arguably implying that human-centric considerations (thus thinking and about designing transport so that all commuters can access it) can promote accessibility to South African PT. PTE1 also emphasises that commuters require the shortest distance between their home and where they access PT services (PTE1:I4). The need of accessibility also strongly relates to considering the needs of the disabled community (PTE1:I5), who often have limited access to PT due to their disabilities.

Both PTE1 and PTE2 make reference to **connectivity, ease of transfers and ease of interoperability**, allowing the commuter journeys from origin to destination to be optimised (PTE1:I4) and make use of multiple transport modes to travel where they need to go (PTE2:I23). Arguably, these needs can be translated into a single term: *convenience*, which considers how a service can be optimised to simplify a commuter's travel journey. Such optimisation of the service design process (as considered in HCDE1:I23) can arguably be related to human-centric service delivery. This insight links strongly to the need for an integrated payment system and electronic PT cards that can be used on "any particular system that you actually come across" (PTE1:I4) so that payments between different PT modes are integrated and thus made more convenient for multi-modal commuters. PTE1's referenced to "ease of payment systems" (PTE1:I4) emphasises this.

PTE1 also made two references to the importance of transport service **availability**, saying that "PT must be available" (PTE1:I4) and insisting that PT services are available nearly locations where commuters can do their shopping (PTE1:I5). When considering the inside of PT vehicles, "the issue of **amenities**, like your ablution facilities on intermodal facilities" should cater for all PT modes (PTE1:I5), **balanced vehicle loading** "depending on the distances travelled" as well as **clean vehicles** with **available luggage space** (PTE3:I7). PTE3 noted that **travel times** have recently started playing an important role in South African PT service provision (PTE3:I7), while HCDE3 believes **good maintenance** of PT infrastructure is also important to consider (HCDE3:I17).

1.1.1.1.1.1 Attracting customers to South African public transport

All three PT experts as well as HCDE3 believe the fulfilment of the key personal and travel needs of commuter will "definitely" (PTE3:I8) and "[u]ndeniably" (PTE2:I6) lead to a great desire to use PT services and induce a greater demand therefor. HCDE3 believes transport authorities can only start looking for other improvements once "all the basic boxes that are required for transport" (namely, the needs mentioned above) are ticked, which in turn will bring about elevated customer satisfaction in these services (HCDE3:I17).

Given that these needs are the greatest worries for South African commuters (PTE1:I6), they are the most important consideration to attract customers to PT and encourage them to use a service (PTE1:I7) - proper PT facilities and effective, integrated ease of access to these facilities implies "the demand will be great, much greater; there will be a *surge* in demand." (PTE2:I6) Linked to this, PTE2 says that when travel times, number of transfers and routes are "redesigned to meet the passenger demand" (thus upgrading the old, rigid PT system), "there will definitely be a big appetite from passengers" to use PT (PTE3:I8).

PTE1 notes that these trends are relevant only to the middle-class who have a choice of mode – not captive users who do not. A good example of the above limitation is the Gautrain, which "actually managed to attract private car users from their cars into the train" due to the time factor, since "it's much faster to travel from one area to the other than using your car" (PTE1:I6). While being limited to the middle-class, addressing all the needs discussed above would also positively transform the public's view of South African PT, and through provision of modern PT infrastructure that is "really attractive to young people in certain demographics" and installing Wi-Fi in PT spaces, "you might actually attract people to use PT." (PTE1:I17)

4.1.4.1.2.2 Harnessing innovation in transportation and why it is lacking

HCDE3 reminds us of how people embraced the arrival of Uber™ in South Africa, noting that South Africa is getting innovations from elsewhere and should thus make a greater effort to discover innovation locally (HCDE3:I16). When using PT, "what people actually want is a pleasant environment to be in" – "an undecorated government building is not anybody's idea of a nice experience" (HCDE3:I24).

As discussed in the 'Poor policy implementation' and 'The stagnancy and rigidity of South Africa's transport system' sections above, one of the primary reasons for a lack of policy implementation as well as progressive development of South Africa's PT system is a lack of available funding (PTE2:I12; PTE3:I10). HCDE3 supports this view, claiming limits on resources result in governments not thinking further than "old school, bland government-style train station[s]" and thus not holding space for innovation. An innovative solution for this issue is provided below.

If local municipalities could "pay guys to come and do beautiful tiling, or well-known artists", or host community competitions where people submit creative ideas to add character to the community, HCDE3 believes available funding can be utilised effectively to foster the level of innovation South African PT desperately needs (HCDE3:I27). "[T]rain stations that feature local art" really "makes it feel like a community space, and is actually nice to be in", very likely affecting people's perceptions of that PT service (HCDE3:I24). HCDE1 believes that by creating things that people desire, businesses can successfully offer the level of innovation they desire and, as a result, experience the growth they are aiming to achieve (HCDE1:I20), while PTE1 says satisfying commuter needs is the most important consideration to encourage commuters to use a PT service (PTE1:I7). Based on these two insights, making an "investment in

infrastructure that recognises human desires" (HCDE3:I24) may in fact offer transport businesses the increased patronage and growth they desire.

A concluding recommendation is provided by HCDE1 for businesses to foster the innovation they desire. HCDE1 believes if businesses follow the precursor of "Wouldn't it be cool if…?" in their design thinking, they are on the right track to promoting innovation and development. This is because they are using their imaginations to create an ideal, desirable solution (HCDE1:I37) that, according to HCDE1:I20 above, is what *people* desire, in turn offering these businesses the growth they are aiming to achieve.

4.1.4.1.3 Subtheme 3: Expert recommendations for PT development and their associated benefits

A total of 26 insights (12% of total 217 insights considered) were designated as recommendations from both HCD- and PT expert on how to promote PT development in South Africa, including insights on PT network integration and its benefits. A portion of over 10% of the insights indicates that experts have an awareness on how to resolve existing transport issues in South Africa and have begun considering how network integration can proceed, as well as how such integration can offer solutions to these issues.

4.1.4.1.3.1 Recommendations, insights and priorities for South African PT development

PTE2 asserts that *certainty* is a crucially important consideration for South Africa's current transportation development (PTE2:I14). One way of improving such certainty in transportation is countering the fragmented transport provision, which PTE2 believes can be achieved by setting up a "transport authority that's independent of the government changes, so a transport authority manages everything transport." Due to indecisiveness on this part, South Africa only has one transport authority that is "sort of" constituted so far – the Gauteng Transport Authority (GTA) (PTE2:I9). Another way of boosting certainty in the transport sector is that, when approaching a problem, transport service providers should **never assume** they know the answer. PTE1 explains that by assuming, one closes off a route of enquiry and thus limit the problem-solving process (HCDE1:I8).

References to the safety and security of South African PT at this time were made by PTE1 and PTE2. PTE1 explains that some areas in Gauteng are more secure than others, so the security cluster (that includes the operators themselves and private entities who own certain area) really need to "step up and come up with solutions to make certain places secure. It's not like we do not have the expertise to actually do that, it's just that there's no real leadership and effort in that direction to make the places much more secure. And that requires quite a lot of determination." Technology like CCTV cameras with facial recognition software are currently available and getting increasingly cheaper, so PTE1 insists that such technology is deployed in more dangerous areas to "expand those pockets of excellence into other areas and make it much more common that security is a top priority." (PTE1:I19)

PTE2 adds to this stating that, under COVID-19 conditions, the "provision of safe, compliant, COVID-related PT is *paramount*", so it is essential that the public has access to this quality of PT during this time (PTE2:I17). Arguably, the public can be made aware of the importance of COVID-safe PT service by effectively communicating with them. Authorities can communicate with commuters over local radio stations, community newspapers, pamphlets given out on the modes or TV screens on modes (especially busses) where specific messages can be expressed. Installing Wi-Fi on busses can also provide service providers with online, real-time information, which PTE3 believes is "lacking in a huge way in the commuter environment at this stage." (PTE3:I24)

HCDE1 advises that background research should always be done when attempting to solve a problem, so that the current context can be understood and enable authorities to follow an iteration process when collecting data. Rather than following a rigid protocol that limits the richness of the data one can collect (namely, the anthesis of HCD), iteration allows one to delve into new routes of enquiry that were previously unconsidered (HCDE1:I9). When attempting to derive solutions to an issue, HCDE1 believes "an incredible amount of honesty, and belief" is required to make service providers aware that their design could be done in more effective way, in turn improving the quality of their products or services (HCDE1:I23).

In order to positively evolve South African PT, it can be argued that policies need to be created and implemented to support that growth. PTE1 explains that the preamble for any policy is the recognition that systems being implemented are being implemented for human beings, who "have got certain, particular characteristics and needs." This policy change would then change how authorities come up with transport solutions (PTE1:I19). PTE3 believes another form of evolution required in the transport industry is that commuters in communities are provided with a training or awareness that there aren't unlimited resources available from the transport service providers' side – they operate under certain limitations (PTE3:I23). This will help the commuters in communities, overall, appreciate the transport service that is being rendered to them (PTE3:I16).

4.1.4.1.3.2 PT network integration – benefits and insights

The National Transport Act (as it is now called) "is the document that is driving the way PT *must* be implemented" in South Africa – within it lies the IPTNPs (PTE2:I34). PTE3 believes funding is the highest priority to implementing these network integration plans, so authorities "must also make sure that the funding is available to give effect to these plans." (PTE3:I31) Even if authorities don't have the funds to provide for *all* commuter needs or integration plans, they should attempt to at least cater for, say, 70% of the requirements and address the other 30% later on when they can afford it (PTE3:I35).

As discussed above, PTE2 states that "*ease of interoperability* within an *integrated* transport network" is an equal priority to safe, affordable and reliable transport, as commuters would prefer to use multiple

modes to travel where they want to go and "will have no problems paying for that as long as they know it *works*, but right now it doesn't *exist*." (PTE2:I23) Before the taxi industry can form part of the upcoming IPTNPs, they require more exposure, training and understanding of business moving forward (PTE3:19). Another key obstacle to network integration is that the DoT has allowed "allowed certain operators to become too big", meaning the facilities created by these operators "have become pivotal to the success for PT service provision." Thus, the DoT cannot unbundle the infrastructure and services of these operators to step towards integration because they need these facilities to be in operation (PTE2:I13). PTE2 explains that transport operators will only buy in to be part of the IPTNPs once the government departments are skilled and capacitated to implement these plans, thus providing a sense of certainty in terms of the PT policy (PTE2:I11).

Once South African PT is seamlessly integrated, it will contribute a great deal to the country's economic growth and wealth opportunities, as well as industry growth and job creation offered by mobility (PTE3:I17). Proper integrated transportation can promote financial benefit "to a *big* extent" by eliminating inefficiencies such a service duplication, thus better planning, coordinating and optimising all PT services. As a result, patronage will rise and dependencies on subsidy will fall because transport vehicles are being utilised more, and services are operating more regularly, thus offering the financial benefit suggested (PTE3:I32). A proper integrated PT plan will enable taxis and busses to act as feeder services for the train, making a great deal of funds available that will make development and evolution of the system more affordable (PTE3:I11).

PTE3 is "a firm believer that integration will resolve a lot of problems in the industry", but *all* role players will have to make sacrifices and commit to being "part of the resolution for the betterment of the commuters." The latter can be achieved through co-operations, "joint ventures and joint shareholding for new companies to be formed" (PTE3:I16). However, every time integration occurs, the bus and rail industries suffer job losses, so labour and job security are key integration obstacles for these modes (PTE3:I20).

Another key concern that complicates and prohibits network integration is planning from the transport authorities' side. In fact, this is missing link between commuters *stating* their needs and desires and those requests actually being *implemented*. As a result, PTE3 believes the inability to address commuter requirements results from a lack of "integrated planning offices at local municipality level", even though such planning or direction to implement integration plans is a requirement within the IPTNPs. In support of PTE2:I11, transport stakeholders will only start contributing to the successful implementation of these plans once local role players are involved and the planning authorities get their affairs in order – without these planning offices, integration plans will not progress (PTE3:I30).

PTE3 offers a simple yet innovative solution to this issue: municipal integrated PT control centres. These centres are suggested to exist on a smaller scale in municipalities and on a centralised basis, eliminating human intervention by electronically (and thus automatically) monitoring, managing and communicating with PT vehicles. Herein, busses and taxis feed into rail transport, meaning their timings should be synchronised so that feeder services leave punctually and arrive at the train station just before the train leaves (PTE3:I39).

In the event of exceptions such as bus breakdowns or late arrivals, drivers should be able to communicate with the control centre to inform them of the exception so that the rail service can be held back, and commuters are swiftly informed of any schedule changes (PTE3:I39). Additionally, effective communication between drivers and the control centre should be maintained so that control centres can communicate with waiting commuters to arrange alternative means of transportation, if necessary (PTE3:I25). Electronic management of PT services in each municipality will also assist the Department of Transport in managing the controls of PT vehicles per kilometre. Such a control centre will also be linked to an integrated fare system of the modes involved (PTE3:I39), while an integrated PT application to communicate with commuters (wherever they may be) can be provided in conjunction.

4.1.4.1.4 Subtheme 4: The role of HCD in South African PT development

The qualitative interviews provided several examples of successful HCD application and the benefits it brings to businesses of all types, including PT services. An argument is also presented on how HCD would be capable of fulfilling South African commuter needs, in addition to overcoming obstacles that would limit the incorporating of more human-centric thinking in South African PT design.

4.1.4.1.4.1 Successful application of HCD and its consequential benefits

A HCD specialist begins a workshop by bringing together the stakeholders of the issue at hand and identifying the issues and problems they face. These stakeholders provide reliable and innovative design insights during these workshops. Next, insights obtained are distilled to identify the considerations or aspects that would most beneficially promote transformation. At the end of the workshop, an array of different solutions has been identified (HCDE1:I25).

To test the viability of the available solutions, experts of the particular field are contacted to evaluate whether these solutions could solve the problem at hand, as well as whether they can be carried out in a technical sense. If the experts believe the solution is viable and can be created, the HCD company begins developing a product to address the issue at hand (HCDE1:I25).

Since the process is centralised around involving all relevant stakeholders of an issue and determining what problems they face, HCDE1 believes HCD is "the *ultimate* democratic process." (HCDE1:I29) HCDE3 says the

use of HCD in South Africa's service provision would resonate better with customers because it is addressing both what people need *and* desire, stating that "[y]ou're more likely than not to get a better outcome" when using HCD (HCDE3:I22). HCDE1 also believes using HCD would increase the demand for a service, as empathising the needs of one's clients allows the service provider to identify core desires and thus allow them to be completely fulfilled (HCDE1:I14). Furthermore, HCD is a great way to be innovative and discover unmet desires in your consumers or clients that you haven't seen before, allowing businesses to change directions and offer a service that meets these needs just be knowing what they are (HCDE1:I19).

Because empathy is central to the HCD process, incorporating more human-centric thinking in South Africa's overall service provision would offer "[e]fficiency, both for client and provider side" and creates a system that is easier for employees and customers. Because "interpersonal interactions have improved", working conditions improve as well, creating a better experience for both customer and employees. HCDE3 reminds us that people are far more likely to recommend and make use of a service where the employees are happy and the service is efficient than one where employees are grumpy and the experience is unenjoyable (HCDE3:I23). The HCD process determines what stakeholders want and obtains their support therein, implying HCD actually alleviates risks, immediately securing a stakeholder's buy-in to the cause. The designs emerging from an HCD workshop are inspired by people, so it is more likely that they will satisfy customers, thus eliminating the risk of failure and thus improving the chances for project success (HCDE1:I35).

4.1.4.1.4.2 Cases of successful HCD utilisation

An architect from KwaZulu Natal named Rodney Harber used a participatory methodology when designing markets for informal traders in Durban. Instead of following the design process he was expected to (and that other architects followed), he insisted on talking to informal traders at the beginning of the process prior to beginning with the market's design so that he could understand their core needs and considerations before designing the market (HCDE2:I30). Another brilliant example of human-centric service provision is the innovative, world-renown Apple™ company. HCDE1 believes this is enough proof that HCD carries the potential for innovation and business success, as it listens to customers and attempts to understand their core needs, struggles and fears. This is exactly what Steve Jobs did in the era when computers were highly technical, counter-intuitive and difficult to use – "[h]e's created an entire business on the basis of the ultimate HCD" (HCDE1:I36).

Another example of companies "trying to be more people centred" is when schemes are developed that give workers a portion of the company's shares. HCDE2 says "there are cases when it works reasonably well and the workers are reasonably happy, and they've had a lot of peace in that business or that industry". Unfortunately, in some industries, "the employers manipulated that system and then workers distrusted

them completely" (HCDE2:I30), suggesting that human-centred approaches should be done with the pure intent of serving the needs of workers – benefits will present themselves.

4.1.4.1.4.3 Incorporating HCD into South African PT design

HCDE1 says that their clients using the HCD process the first time stress a great deal because the process is not rigid, and the product cannot exactly be seen (HCDE1:I26). Often, clients (specifically in the private sector) want to see the process or designs that HCDE1's company uses, and very often get told that they don't have one because they don't know what the challenges are and what they're solving for (HCDE1:I24). Being told to trust the process and be patient, these clients are blown away by the results of the process, as it wasn't *nearly* what they expected and solved the problem at hand (HCDE1:I26).

Because HCD is an unusual, iterative process, clients can only see the benefit of it at the end of the process, calling for "people to have a leap of faith in the process." Therefore, the biggest challenge in adopting more HCD is getting people to buy into it, mostly because the HCD process is not understood (HCDE1:I24). HCDE3 believes HCD is actually "more tangible than research when your outcomes are products or redesigned systems or prototypes that actually do something", so clients tend to the embrace the HCD process once they've had the experience (HCDE3:I12).

Currently, the South African government plans to "introduce a single-platform, multimodal integrated ticketing system", where the user is subsidised instead of the operator. These are the most vulnerable people in the network who are often captive to the system because they have no other alternatives, so the government subsides them to cater for their needs. PTE2 argues that this is the limit to which South African PT incorporates HCD (PTE2:I29). Nonetheless, HCDE1 believes that HCD is the way to cultivate the ideal transport culture in South Africa (HCDE1:I33), supported by PTE1 who believes incorporating more human-centric thinking into South Africa's PT services would be palatable for commuters because "it's in their best interests" and "will resolve their challenges." Most of the challenges commuters face are centred around their particular needs, so commuter will actually demand more human-centric service provision - "it actually then becomes attractive because it resolves their problems." (PTE1:I15)

While more human-centred thinking in our PT design will be capable of meeting the unmet needs of commuters, PTE1 cautions that this can only happen if three factors are synchronised: the design, implementation and operations of PT services. It is believed transport service providers will ultimately not have a good product if the above the factors are not linked - upholding good maintenance standards throughout the lifecycle of one's design is also important (PTE1:I10). Meeting the demand of the PT customer is vital in order for South African PT to become more human-centric, as PTE3 believes developing PT around the needs of passengers will promote "a *lot* of benefit moving forward". It is argued that most private car users (including PTE3) would prefer to travel using PT if they are offered a service that they

actually desire, but instead are forced into their cars because no PT is available that meets their needs. Therefore, reutilisation of available transportation will play "a major role in the whole development of the country moving forward." (PTE3:I33)

The cultural beliefs and views of the South African public on PT is also seen to be a major obstacle to human-centric transportation. In order to incorporate more human-centric thinking into South African PT, the existing cultural belief that one can only be recognised as successful when they have purchased a car must be overcome, and shifted so that citizens can understand that they can still be considered wealthy if they use PT. Especially with the youth, "you have to then make PT much more fashionable" and thus positively transform their cultural view of PT so that they want to use it – the case of the Gautrain is seen as a good example of this (PTE1:I16). PTE2 adds to this view, stating the Apartheid era (in particular) has formed a stigma that commuter transport is, arguably, only used by the poor (PTE3:I8).

The public's view of PT can be positively transformed by addressing the commuter needs discussed in ST2 (PTE1:I7) and redesigning travel times, routes and number of transfers to meet the passenger demand (PTE3:I8). Giving PT infrastructure a modern look is also "really attractive to young people in certain demographics" and installing Wi-Fi in PT spaces "might actually attract people to use PT." (PTE1:I17) HCDE3 asserts that "increasing the understanding of the shared need and use of transport" is vital, as "the minute we start feeling a bit of pride in something, we tend to be a lot more forgiving as well, of fellow users." (HCDE3:I24)

PTE2 says that order for South African transport culture to evolve to incorporate more human-centric thinking, "[t]here needs to be a shift, whilst keeping equilibrium, from *profit*-driven to *service*-driven." This then changes the entire focus of the company's employees. Currently, there is merely an "element of emphasis of service provision", but when companies become "*service*-driven to enable profit", "it's not about cost *cutting* or cost *management* – it's about providing a service." In order for that to happen, all parties (primarily the government) need to start thinking in this way (PTE2:I30), which is supported by HCDE2 stating that "they need to get the same message from everybody." (HCDE2:I44)

PTE2 explains that transport solutions emerge from the 'think tank' of South African service design where government, transport engineers and transport economists come together to create solutions (PTE2:I26) but recommends that this team of policymakers includes an individual or team with human-centric skills, such as a psychologist or HCD specialist. This component of the design team can talk to customers, listen to their needs and understand what is important to them, while the other professionals focus on the transport design. That way, the core needs of the human being is being considered in the design process, while systems-based experts can apply *their* expertise to the project of interest (PTE2:I26).

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Similar to PTE1:I10, PTE2 says policy changes like these need to be considered where the policy, design and implementation thereof comes together (PTE2:I26), stating that this shift can only occur if all parties (primarily the government) start thinking in this way (PTE2:I30). HCDE1 claims their greatest successes in implementing HCD solutions came from CEOs of a company who gives permission for changes to occur, meaning the entire company accepts the process and is willing to incorporate more human-centric elements into their service delivery. As such, buy-in from stakeholders at the top of a company's command chain is essential (HCDE1:I30).

4.1.4.1.4.4 Helping authorities become more accustomed with HCD

Because HCD is an unusual, iterative process (HCDE1:I24) and not understood (HCDE1:I24), HCD experts were asked what could be done to help transport authorities become more accustomed with HCD and discover the benefits it holds. HCDE3 believes "[t]he first thing you should do is make the designer or the provider be a regular commuter", so that those responsible for a particular system use the system, experience what their users experience on a daily basis and feel what they feel. It is stressed that this should be done genuinely for the designer's own personal benefit so they can experience what it is *actually* like to use the system - not to showcase a false, made-up version of the system as government officials often do (HCDE3:I25). It is believed this same approach is the key to creating a willingness to shift from systems thinking towards more human-centric transportation (HCDE3:I28).

HCDE2 believes "people don't do it out of the goodness of their heart - they do it because they don't have alternatives", suggesting that South African transport authorities need to run out of options before adopting more human-centric transportation to resolve their existing transport issues (HCDE2:I44). HCDE3 offers two more interesting, yet unusual, ideas to get scholars and authorities to experience the benefits of HCD. A recommendation is made to get stakeholders of a situation (whoever they may be) into a cocreation workshop together, as people experience the benefits of HCD when they are taken outside of their comfort zone, experiencing a change in mindset as a result (HCDE3:I13). The use of plot-twist tricks used by fictional writers was also suggested, which involves setting up an ideal scenario for readers and then, last minute, throwing in a plot twist that people didn't expect and can make sense of (HCDE3:I14). It is believed that evidence must be provided for whatever solutions are proposed and "story telling is a great way of doing that" (HCDE3:I15).

4.1.4.2 *Theme 2: Inadequate stakeholder consultation in transport service provision*

Comprising of 47 insights in total (21.7%), the second qualitative interview theme generally considers how public consultation in transport service provision has been lacking and discusses the importance of including the opinions, views and contributions all relevant stakeholders in the PT design process.

4.1.4.2.1 Subtheme 5: Poor public consultation in transport service provision

A total of 10 insights (4.6% of the 217 insights considered) relate to the South African government's insincere public consultation during the design process and how municipal workers find their safety and empowerment in organisations that represent them and allow them to have their voices heard.

4.1.4.2.1.1 Lip service from the government – insincere public consultation in the design process

It is interesting to note that the term 'lip service' was used three times by experts in Phase 1, which HCDE2 believes the South African government has become "*very* good" at (HCDE2:I25). PTE2 explains that authorities give their commuters "*lip service*" to state they will design the service based on their needs and perspective, having people believe that they listen to their commuters during the design process but end up not doing so (PTE2:I22). This view is supported by HCDE2, who says the government explain how they successfully consult with the public before implementing a plan but fail to follow a legitimate bottom-up approach when doing so (HCDE2:I25).

HCDE2 says transport industries or municipalities in South Africa only consult the public *after* they have completed a proposed plan or design, making decisions on behalf of the public - in their absence - and "to give lip service to give some consultation, they call a meeting" and present to the public "what's already agreed and decided" upon. This is believed to be a "very insincere type of a consultation" (HCDE2:I7). HCDE2 states that authorities never understand what is meant by a "bottom-up, people-centred approach", always thinking they had done so through "this last-minute consultation thing" (HCDE2:I12).

HCDE1 attests to that, saying the South African government consultation with the public when considering proposed plans or policies cannot be compared to a genuine HCD interview. Herein, the interviewee aims to identify what the participants need from the community at that point, and what can be done to improve their quality of life (HCDE1:I18). A bottom-up approach comprises of "consultation *throughout* a process:" from the time that something is being planned until it is developed. (HCDE2:I12). PTE1 says that while there are attempts to incorporate more HCD in the design process that companies use, "it's really not human-centric, the way you are putting it - it's more almost like tweaking the legality systems that we have." Therefore, it can be argued that there doesn't seem to be focus on more human-centric service delivery (PTE1:I11).

4.1.4.2.1.2 The power of the people – the importance of municipal worker organisations

HCDE2 says that "[a]ll municipal workers who work for the municipality have an issue with harassment" because their working conditions are not properly regulated (HCDE2:I3). When authorities get many individual complaints, they are "pretty much free to do whatever they want with them: ignore them if they want to." As such, it is vital to organise municipal workers into collective groups that "that have a bit more force than individuals have when they go and make complaints", otherwise their complaints and queries can be ignored by authorities (HCDE2:I4).

For the above reasons, municipal workers like street traders often "go for some form of collective organisation because that's the only way they can get their voice to be heard." Since they don't have money, their "collective people power" is the only way they can confront "the power of capital and big businesses". Thus, "having some form of organisation" and a "collective voice is key", but often requires "some form of moral persuasion with it." (HCDE2:I13). It is explained that the primary reasons employees in industry strike is because "they just haven't bothered to pay attention to what their workers think." Unfortunately, companies using top-down approaches play unions off against each other, purely "because they're scared of the strength of unions" (HCDE2:I29). These insights explain the importance of sorting municipal workers (including street traders, waste pickers and taxi drivers) into municipal worker organisations so that they are not overrun by powerful companies with abundant resources, and so their voices can be heard and taken into account during the design of PT in South Africa.

4.1.4.2.2 Subtheme 6: Incorporating relevant stakeholders in the PT design process

A total of 37 insights from the qualitative interviews (17.1%) related to incorporating all relevant stakeholders (including commuters, authorities and service providers) into the design of South African PT services. Just over a sixth of the qualitative interview insights (16.7%) related to this topic, showing that experts in Gauteng are well aware of the importance of including commuters in the PT design process and the collaboration between various transport authorities for benefit of South African PT

4.1.4.2.2.1 The role of commuters in the operational success of South African PT

PTE1 believes "the commuter is actually central to the success of PT operations" (PTE1:I1) and their cooperation and support for the interventions that are offered is "central to the success of the system; very much at the core of it." (PTE1:I3) The first thing to consider when developing a PT intervention is whether commuters actually *need* this intervention, followed by whether commuter's acceptance of that particular intervention. If you develop a solution without finding out exactly what the commuters prefer, "you might end up with a solution that nobody really uses." (PTE1:I1) Furthermore, if commuters do not accept your solution, "you will have a very serious problem here" – the current issues with E-tolls are given as an

example (PTE1:I3). Furthermore, it is believed a commuter's behaviour around a PT system "has a lot of impact on your PT operations." (PTE1:I2)

PTE2 says the role of a commuter is central to the formation of trends in PT, linked to the "usage, ridership and timings based on price sensitivity" as well as service levels of a particular mode. "Unrelated issues are ventilated in a PT space", so "if there's a dissatisfaction with service levels, the community would vent that by either burning busses or not" (PTE2:I2). A commuter's support and respect for the transport system has a big impact on the operational success of that system, as commuter fare collection contributes to a large portion of the transport service's sustainability; the rest is subsidised by the government. Therefore, "if there's a resistance to fare increase, that could effectively debilitate an operator or company providing the service ongoing." (PTE2:I3)

Unfortunately, the role of the commuter in the operational success of South Africa's PT system is currently very limited – they are users and are treated as users. As such, PTE2 believes the role of the commuter is "primarily to ensure compliance to the legislative requirements as a user of PT of whatever form". However, while being limited, "the role of a commuter can seriously impinge on the success or the trends with ongoing sustainability of PT", meaning if an incident occurred in a particular mode, people would ("from an emotional and psychological" perspective) move to other modes. Thus, if there is no support for that mode, "that would translate to no demand, so a reduced need for that service." (PTE2:I10) Nonetheless, PTE3 believes the commuter should have "a critical input in the planning and positioning of transport moving forward" in order for their requirements to be taken into consideration, as one "can't just develop a new transport system without their inputs." (PTE3:I2)

However, PTE2 believes the psyche of South African commuters is such that they believe they have to live with what they are given, while expressing their satisfactions with the service they receive. As such, commuters don't realise how much power they have and essentially do not think they *can* make a difference (PTE2:I5). However, HCDE1 believes increase customer satisfaction with South African PT services can be brought about by speaking to the people that use it and being bold about doing so. HCDE1 estimates that nearly every car user in South Africa would prefer paying a small amount in tax every month to make use of a slick, connected and effective PT system, instead of owning and having to pay off a car. In that case, they would also be free from the expense of car insurance and having to deal with road rage (HCDE1:I27).

4.1.4.2.2.2 Prioritising people-driven development

HCDE3 believes "[t]he need for some kind of people-driven regulation is probably the most key thing" to consider when developing South African PT, as top-down regulation (as was exhibited by the DoT at the taxi *lekgotla* in 2020) was a complete failure and the "government's been doing that for *years*." Moreover,

HCDE2 thinks "the only way to break through will be something whereby the voices of the people on the bottom" (namely the customers) are heard (HCDE2:I20). This correlates with the view of PTE3, who says one of the longstanding issues for South African commuters is that they voice their concerns, explain their needs and make suggestions, yet their "suggestions are never implemented, or only implemented partially", "swept aside from the company's side." Thus, PTE2 believes listening and acting on commuter's concerns and suggestions "will definitely play a *major* role moving forward, and make sure that we render a service that they expect." (PTE3:I29)

PTE3 says that it is important to be sensitive towards commuters when implementing a transport design, as current issues are due to historical circumstances and will thus take time to address completely. As time evolves, it is believed service designs must be adjusted "according to your commuter patterns and requirements." (PTE3:I38) While stating that inputs from commuters on service improvements are currently "very limited", PTE3 says taking into account the wishes and requests of commuters results in an immediate positive reaction towards the interventions received, the impact shown through rising patronage and revenue from the services (PTE3:I21). HCDE2 notes that people-driven regulation "would get much more compliance from everybody in the industry including the [taxi] drivers", as existing regulations exist yet are not complied with (HCDE2:I21).

4.1.4.2.2.3 The importance of proper consultation and negotiation with relevant stakeholders

One of the improvements offered by HCDE2 to bring about elevated customer satisfaction in South African transportation is building in stakeholder's consultation into the PT design model (HCDE2:I42). This view is supported by HCDE1, HCDE3 and PTE3, believing consultation with all relevant stakeholders of a certain context is recommended to find a solution collaboratively and effectively (HCDE1:I3), really good ideas are discovered through diverse, facilitated interaction between a mix of people (HCDE3:I2) and *all* stakeholders (including the community, commuters and service providers) should be involved from the onset of a human-centric process (PTE3:I37). Given that four of the six experts interviewed support this view, proper consultation and negotiation with relevant stakeholders during the design process should be considered an important priority for South African PT development.

However, HCDE2 believes that consultation makes people in industry uncomfortable "because they have a weakness" therein. Currently, there are a great deal of problems with communication and consultation, which is why the issue of negotiations are being delayed. While many businesses in the public sector know how to negotiate, there is a great deal of "naivety when it comes to municipal officials", who "just really don't have a clue how to communicate besides give instructions." (HCDE2:I39) Furthermore, HCDE2 reminds us that the idea of negotiating is not new, and requires "some sturdy and sustained efforts", but when done correctly, good consultants "could make quite a difference" in negotiating with unexpected

parties and achieving excellent results (HCDE2:I40). Moreover, a plan is more likely to succeed if everybody is "pulling in the same direction" (PTE3:I37).

HCDE3 believes diverse, facilitated interactions between a mix of people are the key to unlocking the solutions dormant in people's minds, but it is important that they are "at one stage familiar with the community's perspective" on the matter of interest (HCDE3:I2). In addition, HCDE2 believes a balance between the MBT, rail and BRT modes in the South African PT can be achieved through negotiations between the different transport parties, stating that there is a greater issue with *competition* between modes than *demand* for PT services (HCDE2:I43). PTE2 says buy-in from all transport role players (including employees, companies and commuters) would result in a great deal of wasted operator running costs (such as vandalization and diesel siphoning) being saved, which "can only benefit the organisation moving forward" (PTE3:I28), while HCDE2 reminds that it is easier to negotiate first than having to first to endure several court cases (HCDE2:I36).

HCDE2 recommends that South African transport authorities "set up negotiating forums, some sort of space where the authorities and the people they are making decisions on behalf of have a regular engagement." Monthly meetings are proposed. It is believed "[t]he same principle could apply in other cases" (HCDE2:I10), even South African transport services (HCDE2:I32). While unions actually promote these sorts of interactions, it is sectors like the taxi industry who tend not to have unions that refuse to participate (HCDE2:I10).

A genuine negotiations process "makes a level playing field", meaning employers are not allowed to give orders and are "on an equal level with the people" they are negotiating with. This means the voices of employers and employees are equally important. Setting up these kinds of negotiating forums requires well-organised people to facilitate the process, because if the weaker party is not well organised, the strong party becomes tempted to "manipulate and control that process", causing the purpose of the forum to backfire (HCDE2:I31). These types of negotiation processes should be done from the planning stage onwards and endure even through challenging issues (HCDE2:I32). Before commencing these interactions, HCDE1 believes organisers should aim to discover an "*alignment of purpose*" so that there is an alignment with the definition of success of all parties. This allows one to come to a balanced conclusion when different intentions exist or there are different views on the matter (HCDE1:I13).

HCDE1 believes it is important to get insights from the entire ecosystem of customers to understand what they really desire (HCDE1:I2), as people have the answers: they just didn't know they knew the answer until somebody asks them. Often, a solution can be just *one* suggestion somebody made that changes the way you look at a situation (HCDE1:I10). Because it is not possible to communicate with all commuters, communities or local council often elect representatives to speak on their behalf (PTE3:I22). When HCDE2

spoke to municipalities who have applied bottom-up community consultation effectively, the people in that municipality say they are "really enjoying the fruits of that kind of collaboration." (HCDE2:I27)

4.1.4.2.2.4 Citizen inclusion, contribution and consideration in the design process

In order to foster elevated customer satisfaction in South African PT services, HCDE3 believes it is vital to "understand the perspective of communities" – people's frustrations cannot be dismissed just because it is unpleasant or uncomfortable to deal with (HCDE3:I19). HCDE3 thinks "getting people used to thinking about the way people behave" at a deeper level would be useful for companies, as they presently do not prioritise the customer – "[i]ronically, the client often comes last in the equation, like you just get what there is." (HCDE3:I26) Therefore, many issues in South African PT may result from excluding, ignoring or disregarding commuters, their needs and their frustrations.

HCDE3 says one of the basic boxes that is not being ticked is that commuters with issues or frustrations are not *heard*, believing this is "incredibly important". Generally, people leave an interaction feeling unsure about their diagnosis, what to do or what to feel if they are treated hurriedly and unkindly because, for a customer, everything boils down to how they are *treated* (HCDE3:I21). HCDE2 attests to this, claiming "[t]he government tends to engage exclusively with the [taxi] associations as if that's their entire industry", but do not consult with the employers of drivers or the drivers themselves. These individuals have many issues they need to deal with since they are the interface with the public (HCDE2:I1).

A reason for this lack of insight could be that the South African government already thinks they know what the core problems of current PT issues are, *and* how to solve them. This view is supported by both HCDE1 and HCDE3. HCDE1 says that people are often not aware of what the core problem to a situation is (HCDE1:I7), while HCDE3 says their clients often assume they already know what the problem is in an issue but do very often not understand the problem well – arguably, industry clients can be compared to the government. From a community's or user's perspective, the "focus is on something different or even entirely different", so it is crucial to first understand what the problem is before looking for solutions (HCDE3:I4). This links strongly to HCDE1:I8, who urges authorities never to assume they know what the solution to a problem is, as they then limit the problem-solving process by closing down a route of enquiry (HCDE1:I8).

If a space is provided where commuters can voice their concerns, their perception of the service will be very different. Service providers can also utilise the information gained in these customer interactions in the future (HCDE3:I21). PTE1 says that with a contribution from every citizen in the country, excellent PT- and healthcare services could be offered, not to mention other useful forms of infrastructure. HCDE1 believes this can be achieved by speaking to the entire *public* about what they need ("it's *public*, right, and public means *everybody*") – if all members of society are not consulted, an opportunity for growth is being

missed (HCDE1:I27). HCDE3 supports this view, saying it is crucial to consider issues in the *entire* transport ecosystem (HCDE3:I19).

4.1.4.3 *Theme 3: Transitioning from systems-centred- to human-centred design*

A total of 45 insights (20.7% of the total 217 insights considered) related to the concept of systems-centred design, perceived value in relation to PT sustainability and mobility-related services (MRS). Reasons why HCD is not often utilised in South Africa also forms part of this theme. The DoT is currently prioritising MRS in the provision of South African PT (PTE2:I15), which is believed to share similarities with HCD due to its people-centred focus. Due to the increasing human-centric focus in South Africa's service provision, this theme considers how South African PT thinking is transitioning from systems-centred design to HCD and why such measures have not yet been utilised.

4.1.4.3.1 Subtheme 7: Systems-centred design: its downfalls, benefits and proposed evolution

HCDE3 believes there should be more flexibility and recognition of a worker's rights beyond their salaries, as their lives are often limited to mostly work and travel. It is believed "humans are being manipulated for the system rather than the system designed to make both workers and customers happy", coining this "systems-centred design [SSD]." (HCDE3:I9) This lack of HCD focus is supported by HCDE1 and PTE3. HCDE1 says the current system prioritises the service of the business rather than the needs of their client and, while there are small pockets in South African industry where HCD is being applied well, it is believed HCD is not being applied *nearly* enough in South Africa (HCDE1:I15). Because the PT design process is mostly process- and funding-driven (comparable to SSD), PTE3 believes the South African commuter is not involved in the PT design process in any way. An example of this is BRT services who are not catering for the people who actually require mass transport (PTE3:I3) – this may be related to PTE2:I32 wherein BRT is owned by ex-MBT and ex-bus operators who are profit-driven.

HCDE2 believes the older form of profit-based design thinking is not beneficial to modern South Africa because "it increases conflict" (HCDE2:I37) and continually limits the potential of South Africa's service provision and customer connection (HCDE2:I38). While this may be so, HCDE3 believes systems-based thinking is definitely still beneficial to modern South Africa, proposing that instead of discarding systems that already exist and starting from scratch, businesses should rather be asking how they can optimise or improve these profit-driven systems by utilising a human-centred thinking process. HCDE3 believes there is a great deal of value in systems thinking, but it requires some "creativity and willingness to take a chance" to manifest the innovation professionals always desire (HCDE3:I11).

Therefore, while experts believe SSD is limiting the potential of South African service provision and increasing conflict, this form of design should not be discarded as a great deal of society's value results

from it. Instead, businesses should ask how their current profit-driven systems can be optimised and more holistically operated through increased human-centric service provision.

4.1.4.3.2 Subtheme 8: The relationship between perceived value and the sustainability of PT

HCDE1 says it is very important to understand what has meaning for a person, as a person will only be interested in something if it is valuable to them (HCDE1:I5). Even PTE1 claims that if commuters are given a system they don't want, they will reject the system (PTE1:I1), a view which is strongly supported by HCDE3 stating that even if people are offered the best product, service or infrastructure, they will not use it if it's not what they want (HCDE3:I1).

HCDE3 explains that clients (in this case, PT commuters) have got to *want* to use the product or service that is being offered, meaning it has got to "fulfil their either conscious or subconscious expectations or desires." A product or service becomes desirable when a client gains a sense of perceived value from it, either personally or emotionally, so HCDE3 believes perceived value is really an important consideration for almost any human interaction (HCDE3:I6). HCDE1 believes the use of more HCD in the country's service provision would resonate better with customers because it achieves what the customers desire: "a service that is *valuable* to them". If services are more valuable to customers, HCDE1 believe they might actually look after it better and be prepared to pay more for it (HCDE1:I28). This understanding forms the core argument of ST8: the perceived value South African commuters gain from PT services affects the sustainability of the services, in terms of who uses these services and how PT infrastructure is treated by users.

An insight from HCDE3 reinforces the above proposed argument. If services are not valuable to customers, there is a greater chance they will be dismissive or damage the infrastructure due to other frustrations they harbour (HCDE3:I20). HCDE3 explains that solutions in a particular context should be feasible, viable and *desirable*, but "what is often skipped out on is the desirable part." (HCDE3:I1)

HCDE1 believes "value" is equal to "desire", meaning if people desire it more, they will value it more and thus be prepared to pay more for it (HCDE1:I20). This insight, in conjunction with HCDE3:I20 above, implies that if South African commuters do not *value* a PT service, then they do not *desire* it, implying they will more likely be dismissive or damage PT infrastructure to express the frustration or dissatisfaction they feel towards the service. Further reinforcing this argument, PTE2 states that "[u]nrelated issues are ventilated in a PT space", so "if there's a dissatisfaction with service levels, the community would vent that by either burning busses or not" (PTE2:I2).

HCDE3's travels to developed countries with efficient, reliable PT services has summoned a realisation that all commuters desire the use of PT or NMT – it is valuable to them (HCDE3:I20). In order to quantify how

much a person values something, HCDE1 believes understanding a person's *perception* thereof is essential (HCDE1:I5). PTE3 explains the benefit of utilising this understanding. If transport services operate and comply with passenger needs, then they "will be successful moving forward." Commuters will then perceive the service as more valuable and be prepared to pay more to use that service (PTE3:I27), arguably because the service is fulfilling their "either conscious or unconscious expectations or desires." (HCDE3:I6)

4.1.4.3.3 Subtheme 9: A comparison between HCD and mobility-related services

When asked whether human-centred thinking has the potential to provide for unmet commuter needs at this point in South Africa's PT development, PTE2 declined by saying "currently, the PT design is on **mobility trends**." It is further explained that MRS design attempts to align the service with the number of people using a service and where commuters are travelling to but is not based on why people are moving there and is limited to affordability of the solution (PTE2:I15). An example of this is provided.

If a new township is built that would require PT services, the transport service desired, the number of people using it and where they need to go would influence the bus schedule (frequency, distance and number of trips), service optimisation and staffing within the company. As such, PTE2 explains that mobility trends and commuter requirements drive "utilisation, planning and asset deployment, as well as labour", influencing "*everything* in the costing model to provide a service." (PTE2:I18). PTE3 contributes saying "there will definitely be a big appetite from passengers" to use PT when travel times, number of transfers and routes are "redesigned to meet the passenger demand" (thus upgrading the old, rigid PT system) (PTE3:I8) – given PTE2's definition of MRS in paragraph one of this section, redesigning the system to meet the passenger demand is indeed a MRS concept.

PTE1 indirectly refers to MRS design by claiming the first thing that can be done to solve unmet commuter needs is to uncover what their actual needs are, how many commuters require a service and "which form of transport would be much more suitable for them" and "would be more suitable to cover their travel needs." (PTE1:I12) Following this, it is believed the highest priority in South Africa's PT and service design is selecting the correct transport solution from the hierarchy of solutions available that would be best suited to a particular transport corridor (PTE1:I13). PTE1 elaborates by saying the human elements is already being considered by transport authorities when considering who requires a transport service, how many people require it, what the demographics are and in which segment of society they live, while selecting the most appropriate form of technology for that particular area is key (PTE1:I14). Again, the insights in this paragraph relate to MRSs.

Because South Africa's current PT focus is on MRS, PTE2 says "anything HCD designed would create additional and different design for PT", so government does not have the funding or focus for a competing interest. PTE2 says only "if we had a *solid* infrastructure in place and a good available funding for PT

network, *that* human-centred thinking would *certainly* influence and amend and affect a lot of changes." (PTE2:I15) Moreover, it is believed it is going to be a "*long time* before we get to a point where human needs design would influence PT design." (PTE2:I19)

However, a counter argument to the above insight is proposed: MRS and HCD are related and mutually inclusive. Above, a general definition of MRS is provided by the three PT experts. In order to support the proposed argument, definitions of HCD (from HCD experts) and MRS are compared to evaluate the similarities between these two seemingly unrelated forms of design and illuminate whether HCD can help develop the current mobility trend priority.

PTE2 believes, however utopianly, that HCD and mobility solutions are related in some ways, both requiring the core needs of commuters as inputs. However, current service design is "based on pure transport, economic and engineering design" and is thus not based on human needs (PTE2:I19). While this may be so, PTE1 claims the first thing that can be done to solve unmet commuter needs is to uncover what their actual needs are, how many commuters require a service and "which form of transport would be much more suitable for them" and "would be more suitable to cover their travel needs." (PTE1:I12) This insight is directly relatable to MRS (as it provides a service based on customer demand) but also to the core principles of HCD: *empathy*.

HCDE1 explains that empathy allows one to understand what one's client's needs are (in this case, PT customers), in order for their desires or objectives to be attained (HCDE1:I12). HCDE3 elaborates with the belief that the demand for a service, for the most part, *does* rise if the company is meeting client's needs, by helping them understand their own desires and how to achieve them (HCDE3:I5). While PTE2 explains how current service design is "based on pure transport, economic and engineering design" and is thus <u>not based on human needs</u> (PTE2:I19), HCDE1 reminds us that all problems and opportunities (also applicable to South African *public* transport) are *human* problems (HCDE1:I1), and that HCD is important since it allows you to identify where the problem lies, as it's not always where we *think* it is (HCDE1:I7).

With the above in mind, and considering PTE2's view in ST1 that the scientific, mathematical and economical package that is currently being used to design South African PT services is "not by any manner or any stretch" addressing unmet commuter needs (PTE2:I28), could it be that transport authorities are assuming this package could resolve current PT problems? HCDE2 says "[w]here people are not looking at the human-centred element, they are acting unilaterally and leaving out people" (HCDE2:I6), meaning the public's views and insights are being disregarded if (<u>as mentioned in PTE2:I19</u>) current service design is not based on human needs. This links strongly to HCDE2's insight in ST5 that transport industries or municipalities in South Africa only consult the public *after* they have completed a proposed plan or design, making decisions on behalf of the public, in their absence (HCDE2:I7).

If the above is true, and the scientific, mathematical and economical package that is currently being used to design South African PT services is "not by any manner or any stretch" addressing unmet commuter needs (PTE2:I28), could the current MRS focus be heading in the same direction? PTE2 states that MRS design is not based on **why** people are moving there and is limited to **affordability** of the solution (PTE2:I15). Often, because service providers can only afford to provide a service between specific times based on mobility trends, commuters are often forced to use a service at times that don't suit them (PTE2:I16); this cannot be considered human-centric, as it is based on affordability of services rather than meeting the core needs of commuters.

Such design can surely be calibrated with HCD to satisfy customers by practically considering commuter needs in the MRS model and using innovation (as concluded in ST2) to make an "investment in infrastructure that recognises human desires" (HCDE3:I24), which may in fact offer transport businesses the increased patronage and growth they desire and resolve limitation of affordability in MRS. However, this can only take place if MRS and HCD are complementary.

Based on the insights presented above, the entire MRS design process is driven by commuter requirements, commuter demand and providing a transport service that meets the needs of commuters in a particular area (PTE2:I18; PTE2:I15; PTE1:I12; PTE1:I13; PTE1:I14). According to ST4, the HCD process entails bringing together the stakeholders of the issue at hand, identifying the issues and problems they face and distilling all insights obtained to identify the considerations or aspects that would most beneficially promote transformation (HCDE1:I25). Experts of that particular field are then contacted to evaluate the viability and workability of these solutions and, if given confirmation, the HCD team begins developing a product to address the issue at hand (HCDE1:I25). Additionally, HCDE3 says the use of HCD in South Africa's service provision would resonate better with customers because it is addressing both what people need *and* desire (HCDE3:I22).

Given the insights synthesised above, a strong argument exists that MRS and HCD are related and complementary. While this will be discussed in more detail in the 'Discussion' section below after Phase 2, if MRS is a priority for South African PT at this point, there is a great likelihood that HCD principles can contribute to the optimisation of the MRS model, by practically incorporating human needs and overcoming a lack of funds using simple innovation, such as an "investment in infrastructure that recognises human desires" (HCDE3:I24). Also, if this correlation exists, there also exists evidence that South African PT is transitioning from more systems-centred, profit-driven service provision where commuter needs are disregarded to more human-centric service provision such as MRSs (hopefully in conjunction with HCD) in which the service model is built around meeting passenger demand and commuter requirements.

Notably, HCDE3 emphasises the importance of being honest with clients (in this case, transport authorities) when the core issue of a certain context is identified, even if they don't want to know, as "no amount of problem solving for something else is actually going to fix the core problem for them." (HCDE3:I5) It should be noted the core problems of a situation are found in fine details of what motivates and drives people (HCDE1:I6) and HCD is "more about behaviour change, as opposed to physical products, necessarily" (HCDE3:I12), relating to the change in mindset people experience from being taken out of their comfort zones (HCDE3:I13) and "what people *learn* in going through HCD process" (HCDE3:I23).

4.1.4.3.4 Subtheme 10: Why a lack of HCD utilisation in South Africa?

The final ST of Theme 3 seeks to understand why a lack of HCD utilisation is present in South Africa overall. A total of 16 insights (7.4% of the total 217 insights considered) referred to how a lack of empathy exists in the public sector and upper class due to the competitive nature of SSD, utilising empathy practically in South African PT and reasons why human-centric approaches are so rarely utilised in South Africa.

4.1.4.3.4.1 A lack of empathy in the public sector and upper class

In one of the first insights of their interview, HCDE1 illuminated the fact that employees in the public sector too often forget about having empathy with their clients or patients. Because the system overburdens them with work, they hardly have time or energy to consider what their clients or patients need, or feel, at the time (HCDE1:I4). While there may exist a form of sympathy of guilt, HCDE3 believes "empathy is really in short supply in South Africa." "[I]f there was a better sense of real empathy, real understanding, then there would be a lot more movement in terms of helping to build a middle class, instead of this sort of continuous reluctance that I struggle to understand." (HCDE3:I8). Arguably, the latter insight refers to the "continuous reluctance" of upper-class citizens.

HCDE3 believes systems-based thinking has indeed fallen short of empathising with the needs of their customers, but not purposefully. Cultivating empathy in South African service design is believed to be a slow learning process (HCDE3:I10), likely because HCD process, and thus empathy, is not understood (HCDE1:I24) and transport engineers are not familiar with human-centric service provision (PTE2:I35). This view is supported by HCDE1, who "undoubtedly" believes that more profit-driven forms of design in South Africa have fallen short in empathising with the needs of their customers. Furthermore, it is believed that the word "empathy" is "underrated and misunderstood" – if people understood what products and services "meant *emotionally* to people, they would approach everything in a very different way." (HCDE1:I22)

An interpolation of this lack of empathy is offered by HCDE2, saying technical people like engineers very often "underestimate the need to consult with the people that don't really understand the technical issues", very often working with people "who *want* to leave out their users" and have a "political invested interest in not talking to the people on the ground." Of course, these plans can very often not "go forward

because there's a complete boycott against it." (HCDE2:I34). An antidote to this issue is presented by HCDE1, explaining that HCD "requires a lot of *integration*, a lot of different types of teams and peoples and expertise working together, and you have to enable that to happen in the most efficient way possible." If all parties working together know what success looks like for the *entire unit*, they can aim to create a system that "allows everybody to know what it is that they need to do" so they can *all* achieve success (HCDE1:I31). Thus, instead of, at worst, deliberately leaving users out of the design process, all stakeholders (including the users and service providers) can collaborate to determine what success would look like for all parties involved.

Such a lack of empathy and care is also exhibited by public systems, who prohibit human-centric elements from being embedded into the country's PT design due to limited, inflexible and the older "bureaucratic way of working" (HCDE1:I31). PTE2 supports this view, as many companies operate rigidly "on an inward-looking basis: 'It's my company, I'm responsible for this area'. They don't talk to one another because of the competitive nature of the environment." (PTE2:I16) HCDE1 says employees focus only on their tiny contribution to the organisation's operation and refuse expand their duty so that their organisation can succeed. Arguably, it's almost as if employees are more concerned with their given job than offering a valuable, successful service to their customer (HCDE1:I31).

An interesting definition is provided by HCDE1 to overcome this limited, older "bureaucratic way of working" in a different light. HCDE1 believes *organisational culture* can be defined by a company's willingness to expand their duty, asking how employees can attend to the needs of their customers and overcome problems or queries, regardless of their context (HCDE1:I32). HCDE3 adds that while being able to empathise with people is fantastic, there "needs to be a practical element to it" – if it is not useful and you are not going to do something about it, then it's pointless (HCDE3:I3). Thus, *practical* empathy must be considered whenever human-centric elements are being integrated into an existing model.

4.1.4.3.4.2 Reasons for rare utilisation of human-centric approaches in South Africa

While there are many *attempts* of applying HCD in South Africa, HCDE3 believe there are not many good *examples*. Good ideas are often "derailed by infrastructure problems or corruption problems" or having to cater to a broad range of people, making the idea's execution more difficult. Once an idea emerges that's "new and marginally successful", the issue is that it very quickly gets commercialised, which is not good for the original business (HCDE3:I7). Because "people are very risk averse" and "business is all about risk", HCDE1 says businesses would be more willing to move towards more human-centric transportation if HCD was proven to be effective through research or best practise. This then provides them with the surety and reassurance that the HCD approach is safe and works (HCDE1:I34).

HCDE2 believes that, sometimes, the reason authorities don't consult with the public on proposed designs or plans is "because they don't know how to do it" (HCDE2:I35), providing a suggestion for lack of human-centric approaches (like consultation and workshops with relevant stakeholders) being used in South Africa. In addition, the reason there aren't many good examples of HCD in South Africa is because the government have "become very skilled in consulting where they already know what result they want" (HCDE2:I23), linking to the insincere, last-minute public consultation done by government to give *lip service* that the public was included in the design process, as discussed in ST5.

HCDE3 supports this view, stating that their clients often don't understand what HCD *is*, often thinking they are already applying it. However, they don't consider that it entails searching for practical solutions *and* testing them (HCDE3:I26). Behavioural change and resource limitations are also seen as obstacles to getting human-centric elements embedded into South Africa's transport system, as limits on resources result in government not thinking further than "old school, bland government-style train station[s]" and thus not holding space for innovation (HCDE3:I26).

In context of the behavioural change aspect mentioned by HCDE3, an example is provided. When PTE2 was asked how the current study could link into mobility solutions and related contexts, the following response was given: "I've never been in that realm of thinking, we've been just thinking about existing policies, what are they doing with it, why are they changing it, so you've stimulated a process that's gonna take some adjusting and take some warming up to, not just from me, but from an entire industry." This response shows that transport engineers are not familiar with human-centric service provision – some experts (such as PTE2) only started considered how HCD could benefit South African PT during the interview! Therefore, the entire PT industry in South Africa will need to first-hand experience the benefits of human-centric PT service provision through concrete research findings and slowly adjust their thinking to embrace the benefits of HCD, so that it can be practically and effectively utilised in South African PT design.

4.1.4.4 *Theme 4: MBT domination in South African PT*

As can be seen in Table 8, nearly 9% of all insights considered in the Phase 1 qualitative interviews related to the MBT industry. While this theme may constitute the smallest portion of the four qualitative interview themes, experts have indicated its impact on the growth and operational success of South Africa's PT system is significant. The discussion within this theme relates to the impact of poor regulation and enforcement in MBT industry on PT success as well as the violence and deception that has taken place in the industry.

4.1.4.4.1 Subtheme 11: Poor regulation and enforcement in the taxi industry

4.1.4.4.1.1 The troubling taxi industry – lack of regulation and enforcement

When asked what the obstacles were that dilute South Africa's PT integration process, PTE3 referred to the dynamics between "the different role players in the transport industry", primarily the taxi industry. Because MBTs are unregulated they, by force, get their way when they create problems (PTE3:I18). PTE2 strongly supports this view stating that "i[f] we [(South Africa)] form and constitute proper and effective transport authorities, then we have to legislate and regulate the taxi industry. There's no buts about that. They need to be brought into a formal, subsidised arena. They have to be regulated." (PTE2:I10) PTE1 has also mentioned that if transport authorities address "some behavioural issues around PT (especially taxis), it could actually be enough to attract users to PT." (PTE1:I6). The fact that *all three* PT experts interviewed have shared their frustrations with the lack of regulation and enforcement in the MBT strongly indicates that this issue is a priority to address, primarily because it sabotages the growth of South African PT.

However, even when attempts are made to consult drivers or their bosses, HCDE2 explains that the South African Taxi Council, SANTACO, "is not very cooperative with anybody", but when it comes to consulting their drivers and their commuters "they'll give a lot of opposition to that." (HCDE2:I13) Moreover, because taxi bosses or employers refuse to comply with regulations (i.e. "tax regulation plus the labour regulation"), nobody, including their drivers, get financial relief from the government (HCDE2:I18). These insights indicate that taxi associations like SANTACO resist any form of regulation, consultation or enforcement, declining any attempt to consult with their drivers. This poses two questions: why do they resist, and what are they trying to hide?

When COVID-19 began, taxi drivers or their employers "weren't able to apply for the UIF TERS [for financial support], because the taxi associations refused to register them", preferring to "pay them under the table in brown envelopes or sometimes in plastic bags." (HCDE2:I2) Until the above-mentioned taxi regulation issues are resolved, HCDE2 doesn't believe "we'll ever get a decent taxi service" (HCDE2:I19).

PTE3 says that the taxi industry needs more exposure, training and understanding of business moving forward in order to form part of the upcoming integrated PT system (PTE3:I19). Arguably, a large portion

of this exposure is following regulations; HCDE2 says drivers are often locked up for going against regulations they weren't made aware of (HCDE2:I8). While "there is existing regulation, compliance with that will be a pretty good start." (HCDE2:I22). Notably, successful consultation with the taxi industry includes ", from the planning stage, both the drivers as well as the commuters" (HCDE2:I13), in which HCDE2 reminds that people-driven regulation "would get much more compliance from everybody in the [taxi] industry including the drivers" (HCDE2:I22).

4.1.4.4.1.2 Common societal misconceptions of MBTs

HCDE2 says that there seems to be a "public misconception that the whole taxi industry is just one industry where everybody has the same interest", failing to see that taxi drivers are "pretty much at the mercy of their employers". Therefore, taxi drivers are not always at fault (HCDE2:I5). In fact, "[i]nformal workers normally want the work to be regulated" because "nobody likes to be in the shadows: ignored all the time, harassed all the time" and jailed for failing to obey regulations they "don't even know about sometimes." (HCDE2:I8) Taxi drivers "want to be registered by their employers, so that they can then have all the benefits that other workers have", and formalised where they are working so that it gets legally recognised. But "because their employment is not recognised, they had to apply for unemployment benefits of R350" when COVID began (even when they are not unemployed!), many of whom couldn't receive this financial support (HCDE2:I9).

Therefore, a greater awareness should be cultivated that very often, taxi *drivers* are not at fault, but rather their *employers* who do not have pure intentions and refuse to regulate them, likely so that they can be manipulated to carry out the orders of their bosses. This introduces the context of the final ST of the qualitative interview themes.

4.1.4.4.2 Subtheme 12: Violence and deception in the MBT industry

When asked to provide improvements to bring about elevated customer satisfaction in South African PT, HCDE2 asserted resolving the issue of taxi violence is crucial, believing it is a "very big thing that causes a lot of the other problems". Besides the recommendation to build stakeholder's consultation into the PT design model, HCDE2 suspects that "technically, all the issues are there." (HCDE2:I42) Due to the taxi violence and route disputes they cause, HCDE3 believes MBTs are an external factor affecting the success of South African transport systems (HCDE3:I18), while PTE3 believes "intimidation" from the taxi industry limits the growth and development of South Africa's PT system (PTE3:I12).

HCDE2 explains that "SANTACO paint themselves as underdogs in relation to big business", yet "their relationships to the people that work for them is absolutely appalling." They're "like a mafia in relation to that". While drivers must be registered "because it's the law", "the taxi associations [SANTACO and the NTA] get by with not complying with the law, with nobody doing anything about it because everybody's so

scared of them." The "violence you see happening between the taxi associations" is "the employers in the industry fighting each other for routes", and if their employees retaliate in any way, they discipline them – "they beat them to a pulp." So, "it's a completely lawless industry." (HCDE2:I15). PTE3 adds that overprovision of taxis on a particular route results in taxi violence (PTE3:I13), linking to the latter insight because overprovision on the turf of another taxi group results in extreme competition to maintain their dominance.

Taxi drivers "have no protection whatsoever" and can only get protection if they are regulated in some way. However, every time taxi drivers get organised and demand to be registered, their employers use "all sorts of spurious arguments" and manipulate them into continuing without being registered (HCDE2:I7). Furthermore, taxi drivers and street traders have experienced issues when their customers refuse to follow COVID-19 protocols. Because they "have no authority to insist", all they can do is ask the person to leave. Then, they get into trouble with their employers because they are losing them business and, as a result, lose their jobs (HCDE2:I7).

HCDE2 believes a greater issue exists with modal competition than the demand for South African PT services – "I understood there's no problem for demand in the taxi industry" (top of p19 in interview transcription). The issue with the rail and bus services is that "the taxi industry has sabotaged them totally", resulting in competition between the sectors – this is why we "need to solve the taxi industry issue." (HCDE2:I43) "The reason there is so much [taxi] violence is because there's so much competition", as "every other form of transport is a threat to the existing industry". Thus, "when new forms of transport emerge", "they attack those new forms of transport". This "kind of lawlessness which is there in general" is "is not conducive to a good sector. So resolving the issue of violence is a *must*." (HCDE2:I20)

By resolving issues relating to the MBT industry, HCDE2 believes the demand for transport can be "more freely distributed across the different kinds of transport", likely offering a change in the transport system where "taxis have a different role" to play. This type of balance can only be created through negotiations between the different transport parties. However, "democracy flies out the window when you have room full of people and only one of them has got a gun, and that person is SANTACO." (HCDE2:I43)

4.1.5 Considerations for Phase 2

4.1.5.1 *Initial list of principles*

According to Step 7 of the research approach in section 3.8 of this study, after analysing the qualitative interview data an *initial list of principles* is defined based on the literature-based principles for either research construct and the qualitative interview data, which are:

1. the most applicable to the South African context and its PT priorities,
2. the most applicable to the study's context, aims and research questions, and
3. the most capable of promoting elevated customer satisfaction, improved service provision and operational success based on current South African commuters needs and transport authority priorities

This selection was done for both HCD- and PT design principles, by first extracting literature-based principles, reinforcing them with qualitative interview data and redefining them. Then, any new principles that have not yet been considered that were emphasised by experts in the interviews were defined and reinforced where possible.

4.1.5.1.1 Initial list of human-centric design principles

4.1.5.1.1.1 Initial HCD Principle 1 - Never assume

Scholars investigating transport service provision in South Africa have found that the solutions offered are often not well-enough linked to the actual problems that need addressing. Therefore, it is crucial to reconsider what the fundamental issues are with PT in South Africa and offer increasingly appropriate solutions that prioritise the travel needs of captive commuters, especially the majority of those living below the poverty line (Oxford, 2013; Mthimkulu, 2017; Thomas, 2016). Mthimkulu (2017) is in agreement with this, stating that it is vital to reconsider what the actual problems are behind PT challenges, so that plans and strategies can be executed differently.

HCDE1 believes this gap in South Africa's transport service delivery is created by service providers assuming they are meeting all their customer's needs and that their product or service is working well, thus assuming that they *know* what their customer's problems are (HCDE1:I21). Thus, transport service providers in South African should **never assume** they know what the problem or the solution is when approaching an issue, as assumptions close off a route of enquiry and limit the problem-solving process (HCDE1:I8). HCDE1 and HCDE3 mentioned that people are often not aware of what the core problem to a situation is (HCDE1:I7), and that their industry clients (comparable to the government) often assume they already know what the problem is in an issue, but do very often not understand the problem well. From the perspective of a

community or user, the "focus is on something different or even entirely different", so it is crucial to first understand what the problem is before looking for solutions (HCDE3:I4).

Literature supports this argument above, stating that understanding and addressing the core problem is a key HCD principle. Often, there may be *several* core issues that cause a problem, and this root cause should be resolved instead of just addressing the symptoms of the problem. By addressing the core problem, it is likely one will address core issues of other problems. Thus, investing resources into solving the correct problem is key (jnd.org, 2019; Babich, 2018). The process of iteration during an HCD process is also incredibly helpful, allowing one to delve into new routes of enquiry that were previously unconsidered (HCDE1:I9) by continually asking 'why?' at each issue until the core problem is reached (jnd.org, 2019).

Thus, instead of South African transport authorities *assuming* they know what commuter's problems are *and* how to solve them, scholars and experts recommend following a process of iteration until the core problem is understood well. Because current solutions are not linked well enough to the actual problems that need addressing (Oxford, 2013; Mthimkulu, 2017), a process of enquiry such as iteration would give authorities greater insight into what is causing the problems at hand and delve into new, unconsidered routes of enquiry (HCDE1:I9; jnd.org, 2019; Mthimkulu; 2017). In turn, **core** transport issues can be addressed (likely resolving other related issues) and apt solutions to resolve them can be suggested, optimised and developed (jnd.org, 2019; Babich, 2018).

4.1.5.1.1.2 Initial HCD Principle 2 – Consider the entire ecosystem

Another HCD principle recommended by scholars is to "think of everything as a system" (Babich, 2018) – HCD experts interviewed agree with this. HCDE1 believes it is important to get insights from the entire ecosystem of customers to understand what they really desire (HCDE1:I2), while HCDE3 says it is crucial to consider issues in the *entire* transport ecosystem (HCDE3:I19). Furthermore, if all members of society are not consulted, an opportunity for growth is being missed – "it's *public*, right, and public means *everybody*" – (HCDE1:I27).

HCDE1 says that with a contribution from every citizen in the country, excellent PT- and healthcare services (not to mention other useful forms of infrastructure) could be offered, but this can only be achieved if all member of the public (however utopian) are consulted (HCDE1:I27). Human needs (such as personal and social considerations) and ecology needs (for example, biodiversity and water treatment systems) are the two interacting parts that make up the urban environment and form the backbone of urban infrastructure development (Yang et al., 2019a). Therefore, it is crucial that both parts (namely the entire transport ecosystem (HCDE3:I19)) are equally considered in order for the urban environment to remain balanced and operational.

In addition, service providers should focus on what they want their users to achieve with their product (Babich, 2018), remember that their users may have different views (jnd.org, 2019) and always remember to test their proposed solutions with real people so that their feedback can be used to optimise the design (Babich, 2018). People have the answers: they just didn't know they knew the answer until somebody asks them. Often, a solution can be just *one* suggestion somebody made that changes the way you look at a situation (HCDE1:I10).

Therefore, scholars and experts recommend considering the *entire* transport ecosystem when developing PT designs and consulting with users therein to derive, test and optimise proposed designs (Babich, 2018; jnd.org, 2019; HCDE1:I2; HCDE3:I19; HCDE1:I27). Consideration should also be given how the proposed solutions would affect the ecosystem in which is it installed so that the human- and ecology needs of the urban environment are catered for and remain balanced (Yang et al., 2019a), noting that "activities do not exist in isolation: they are components of complex sociotechnical systems." (jnd.org, 2019).

4.1.5.1.1.3 Initial HCD Principle 3 - Centralise people's needs, desires and feedback in the design process

Decision-making in transport provision is becoming more oriented around the needs, perception, consultation and satisfaction of passengers (Mitchell, Claris & Edge, 2016; Ko & Stewart, 2002), especially when considering the user-centric nature of *human-centred mobility*, which places the user at the centre of design thinking and aims to benefit both passengers and operators with the provision of organised, durable transportation strategies (Mitchell, Claris & Edge, 2016). However, while inputs from commuters during the transport design process is a requirement, PTE3 says "passengers just never got an input on the product" – "it's always prescribed" (PTE3:I9) – stating that commuters play a limited and rigid role in the operational success of the South African PT system (PTE3:I1).

HCDE1 believes the poor quality and reliability of South Africa's infrastructure is a result of a lack of human-centric service delivery (HCDE1:I6). Supporting this, HCDE2 claims the design thinking behind South Africa's PT service development is flawed "because of a lack of involvement of the human factor", as that "that's what it needs." (HCDE2:I41). Moreover, PTE2 says the scientific, mathematical and economic package that is currently being used to design South African PT services is "not by any manner or any stretch" addressing unmet commuter needs (PTE2:I28), likely because the PT design process is mostly process- and funding-driven, thus not involving the South African commuter in the PT design process in any way (PTE3:I3).

Many commuters claim that PT service providers remain indifferent towards their travel needs and complaints (Lombard & Hugo, 2002), often being employed far away from the transport network, meaning transport services are likely to remain uneconomical and pose financial issues to citizens and local municipalities (TDA, 2014). South African authorities give their commuters "*lip service*" to state they will design the service based on their needs and perspective, having people believe that they listen to their

commuters during the design process, but end up not doing so (PTE2:I22); one of the primary reasons employees in industry strike is because "they just haven't bothered to pay attention to what their workers think." (HCDE2:I29).

Thus, one of the most essential principles of HCD is being "people-centred", including all relevant stakeholders of a situation in the process, interviewing people that live in that community and beginning by understanding their needs and abilities (jnd.org, 2019). HCDE1 agrees, explaining that an HCD workshop begins by bringing together the stakeholders of the issue at hand and identifying the issues and problems they face, then distilling insights to identify the considerations or aspects that would most beneficially promote transformation. These stakeholders are believed to provide reliable and innovative design insights during these workshops. Then, experts in that field are contacted to evaluate whether these solutions could solve the problem at hand, as well as whether they can be carried out in a technical sense, and if approval is given, the HCD company begins developing a product to address the core issue (HCDE1:I25).

Designers should identify the real reason why people want to use their product and understand that that product is merely a tool helping them achieve their objectives in a simpler way (Babich, 2018). Transport service providers must first consider whether commuters actually *need* an intervention, followed by whether they *accept* that particular intervention. If you develop a solution without finding out exactly what the commuters prefer, "you might end up with a solution that nobody really uses." (PTE1:I1) The commuter should have "a critical input in the planning and positioning of transport moving forward" in order for their requirements to be taken into consideration, as one "can't just develop a new transport system without their inputs." (PTE3:I2). In fact, the wellbeing and inherent contentment of citizens is the central goal (but also main trial) of making a city "smart". The promotion of these aspects should be as important to city planners than the technological, engineering focus of their design (Ballas, 2013).

Because "the commuter is actually central to the success of PT operations" (PTE1:I1) and their cooperation and support for the interventions offered is "central to the success of the system; very much at the core of it" (PTE1:I3), centralising their needs, desires and feedback in the PT design process should be prioritised. All three PT experts as well as HCDE3 support this argument, believing the fulfilment of the key personal- and travel needs of commuter will "definitely" (PTE3:I8) and "[u]ndeniably" (PTE2:I6) lead to a great desire to use PT services and induce a greater demand therefor. PTE3 believes listening and acting on commuter's concerns and suggestions "will definitely play a *major* role moving forward, and make sure that we render a service that they expect." (PTE3:I29). HCDE3 says transport authorities can only start looking for other improvements once "all the basic boxes that are required for transport" (namely, their personal- and travel needs) are ticked, in turn bringing about elevated customer satisfaction in these services (HCDE3:I17).

4.1.5.1.1.4 Initial HCD Principle 4 - Practical empathy

HCDE1 illuminated the fact that employees in the public sector too often forget about having empathy with their clients or patients. Because the system overburdens them with work, they hardly have time or energy to consider what their clients or patients need, or feel, at the time (HCDE1:I4). While there may exist a form of sympathy or guilt, HCDE3 believes "empathy is really in short supply in South Africa." (HCDE3:I8) Furthermore, systems-based thinking is believed to have fallen short of empathising with the needs of their customers, but not purposefully – cultivating empathy in South African service design is believed to be a slow learning process (HCDE3:I10), as the word "empathy" is "underrated and misunderstood". If people understood what products and services "meant *emotionally* to people, they would approach everything in a very different way." (HCDE1:I22)

Learning about how people perceive and interpret a problem (cognitive empathy) and "understanding people's behaviours, thoughts and emotions" (emotional empathy) births an excellent design (Mad Pow, 2021). HCDE1 agrees, claiming HCD would increase the demand for a service because empathising with the needs of one's clients allows the service provider to identify core desires and thus allow them to be completely fulfilled (HCDE1:I14), while White (2016) supports the claim that providing commuters with a positive perception of PT services can promote increased use of PT.

However, while being able to empathise with people is fantastic, HCDE3 says there "needs to be a practical element to it" – if it is not useful and you are not going to do something about it, then it's pointless (HCDE3:I3). Thus, *practical* empathy must be considered whenever human-centric elements are being integrated into an existing model. When asked what can be done to help transport service providers become more accustomed with the concept of HCD, HCDE3 believes that providing these service providers with an opportunity to experience *genuine* empathy is key. "The first thing you should do is make the designer or the provider be a regular commuter", so that those responsible for a particular system use the system, experience what their users experience on a daily basis and feel what they feel (HCDE3:I25). It is believed this same approach is the key to creating a willingness to shift from systems thinking towards more human-centric transportation (HCDE3:I28).

Because empathy is central to the HCD process, incorporating more human-centric thinking in South Africa's overall service provision would offer "[e]fficiency, both for client and provider side" and creates a system that is easier for employees and customers. Because "interpersonal interactions have improved", working conditions improve as well, creating a better experience for both customer and employees (HCDE3:I23). Additionally, for a customer, everything boils down to how they are *treated* and whether commuters with issues or frustrations feel *heard* – this is believed to be "incredibly important" (HCDE3:I21).

HCDE2 believes "the only way to break through [from current transport issues] will be something whereby the voices of the people on the bottom" (namely the customers) are heard (HCDE2:I20). Therefore, while maintaining an element of practicality and logicality, cognitive empathy and emotional empathy is vital for South African transport service providers to become more accustomed with human-centric approaches (HCDE3:I28), consider the issues and frustrations their commuters have in a structured fashion (HCDE3:I21) and develop excellent, desirable transport designs (Mad Pow, 2021). Human-centric approaches would increase the demand for a service, because empathising with the needs of one's clients allows the service providers to identify their core desires and thus allow them to be completely fulfilled (HCDE1:I14). This would very likely improve the support for a PT mode and, in turn, the need for that service, translating to a greater demand to use those services (PTE2:I10).

4.1.5.1.1.5 Initial HCD Principle 5 - Enhance a commuter's perceived value when designing

HCDE1 says it is very important to understand what has meaning for a person, as a person will only be interested in something if it is valuable to them (HCDE1:I5). Even PTE1 claims that if commuters are given a system they don't want, they will reject the system (PTE1:I1), a view which is strongly supported by HCDE3 stating that even if people are offered the best product, service or infrastructure, they will not use it if it's not what they want (HCDE3:I1). For this reason, HCDE1 believes the use of more HCD in the country's service provision would resonate better with customers because it achieves what the customers desire: "a service that is *valuable* to them" (HCDE1:I28). HCDE3 explains that solutions in a particular context should be feasible, viable and *desirable*, but "what is often skipped out on is the desirable part." (HCDE3:I1), where "value" is believed to be equal to "desire" (HCDE1:I20).

Therefore, it can be argued that if commuters *value* a service more, they will have a more positive *attitude* towards it – this correlation shall be investigated with commuter in Phase 2. If this is so, the degree to which a commuter values a service translates to their attitude towards it. Scholars have found that the choice to change travel behaviour is linked a commuter's attitudes towards a travel alternative (Ben-Elia and Ettema, 2011), directly affecting the likelihood of selecting a type of travel mode (Gärling, Fujii, & Boe, 2001). Therefore, a positive attitude towards sustainable modes of transport must be fostered in order for more commuters to make the choice of using PT instead of private vehicles. The way PT is presented to the public also affects the success of the network's operation, so improving the attractiveness, sophistication and quality of PT services implies more commuters may become attracted to frequent, guaranteed door-to-door travel services (Nielsen, Nelson & Mulley, 2015; Saliara, 2014; Janic & Reggiani, 2001).

Furthermore, projects such as universal design infrastructure transformation projects have been found to generally produce positive results amongst respondents, one reason being that respondents develop a positive bias towards these upgrades. This then results in respondents being more willing to contribute to

the improvements these projects bring (Aarhaug & Elvebakk, 2015). A product or service becomes desirable when a client gains a sense of perceived value from it, either personally or emotionally, so HCDE3 believes perceived value is really an important consideration for almost any human interaction (HCDE3:I6). If services are perceived as more valuable to customers, HCDE1 believes they might actually look after it better and be prepared to pay more for it (HCDE1:I28), and if people value it more and thus be prepared to pay more for it (HCDE1:I20). PTE3 agrees, stating that if transport services operate and comply with passenger needs, then they "will be successful moving forward." Commuters will then perceive the service as more valuable and be prepared to pay more to use that service (PTE3:I27).

Therefore, as was concluded in ST8, making an "investment in infrastructure that recognises human desires" (HCDE3:I24) may in fact offer transport businesses the increased patronage and growth they desire (HCDE1:I20). Importantly, in order to quantify how much a person values something, understanding a person's *perception* thereof is essential (HCDE1:I5). Therefore, South African transport service providers should prioritise understanding the perception their commuters have of the service they offer and aim to enhance the perceived value of their services, meaning commuters will desire it more and be willing to pay more for it. In turn, this will offer these transport businesses the innovation, increased patronage and growth they desire.

4.1.5.1.1.6 Initial HCD Principle 6 - Collaboration and consultation with stakeholders

Decision-making in transport provision is becoming more oriented around the needs, perception, consultation and satisfaction of passengers (Mitchell, Claris & Edge, 2016; Ko & Stewart, 2002). In the design and development of smart cities, scholars even recommend collaborating with citizens and institutions who are knowledgeable of the history, culture and probable future of the city in order for the city's unique characteristics to be integrated into its design (Lara et al., 2016). Moreover, negotiating and collaborating with the operators of transport services is one way to achieve modal integration in high-demand transport corridors that are dominated by automobiles and MBTs (Shaw, 2006).

The importance of collaboration and consultation are also emphasised by the experts interviewed in Phase 1. HCDE3 says really good ideas are discovered through diverse, facilitated interaction between a mix of people (HCDE3:I2) and that commuter's perceptions of a PT service would be very different if a space is provided where commuters can voice their concerns (HCDE3:I21). HCDE2 recommends that South African transport authorities "set up negotiating forums, some sort of space where the authorities and the people they are making decisions on behalf of have a regular engagement" – monthly meetings are proposed (HCDE2:I10) – explaining that there is a great deal of "naivety when it comes to municipal officials", who "just really don't have a clue how to communicate besides give instructions." (HCDE2:I39)

Furthermore, it is believed that the reason authorities don't consult with the public on proposed designs or plans is "because they don't know how to do it" (HCDE2:I35) and that negotiations between the different transport parties (including the MBT industry) is the only way that the demand for transport can be "more freely distributed across the different kinds of transport", likely offering a change in the transport system where "taxis have a different role" to play (HCDE2:I43). HCDE1 believes consultation with all relevant stakeholders of a certain context is one way to find a solution to a matter in a collaborative and effective way (HCDE1:I3), where an "*alignment of purpose*" should be found that aligns the definition of success of all parties and balance different intentions or views on the matter (HCDE1:I13).

PTE3 believes *all* stakeholders (including the community, commuters and service providers) should be involved from the onset of a human-centric process (PTE3:I37), aligning with the views of Herriott (2011) who says consultation with commuters should be done as early as possible into the design process to avoid the UD system from being ineffective in meeting its stakeholder's needs. HCDE2 supports this argument, saying successful consultation with the taxi industry includes ", from the planning stage, both the drivers as well as the commuters" (HCDE2:I13) and that a bottom-up approach comprises of "consultation *throughout* a process:" from the time that something is being planned until it is developed (HCDE2:I12). Furthermore, negotiations processes between commuters and service providers should be done from the planning stage onwards and endure even through challenging issues (HCDE2:I32).

One improvement offered by HCDE2 to bring about elevated customer satisfaction in South African transportation is building stakeholder's consultation into the PT design model (HCDE2:I42), claiming people-driven regulation "would get much more compliance from everybody in the [taxi] industry including the drivers" (HCDE2:I22). A lack of consistent, statutory examples of proper public consultation is a primary reason for fragmented policy provision (HCDE2:I24) and a lack of good HCD examples results from government becoming "very skilled in consulting where they already know what result they want" (HCDE2:I23). PTE3 also states that a plan is more likely to succeed if everybody is "pulling in the same direction" (PTE3:I37).

Given how insincere and manipulative current attempts at public consultation is, a huge emphasis is being placed on providing effective, well-managed and collaborative consultation between transport stakeholders in order for South African PT to progress and succeed. A genuine negotiations process "makes a level playing field", meaning employers are not allowed to give orders, and their voices are equally important to their employees (HCDE2:I31). Incorporating authentic, collaborative stakeholder consultation into South Africa's PT design model is one means of enhancing customer satisfaction in South African transportation (HCDE2:I42), involving *all* stakeholders of a particular matter (PTE3:I37) and allowing cities to become smarter by integrating their unique characteristics into smart city design (Lara et al., 2016).

4.1.5.1.1.7 Initial HCD Principle 7 – People-centred development

HCD experts that were interviewed provided insight into basing PT infrastructure and innovation on the desires of commuters. HCDE3 says that limits on resources result in governments not thinking further than "old school, bland government-style train station[s]" and thus not holding space for innovation (HCDE3:I27), as those using PT actually want a pleasant environment to be in - "an undecorated government building is not anybody's idea of a nice experience" (HCDE3:I24). Evidence has suggested that the provision of universal design measures and optimised accessibility at transport hubs initiate an increase in passengers using PT services, thus supporting the intention of promoting increased PT service use (Ruud et al, 2008), showing that design interventions that benefit one type of commuter may very well benefit all commuters and increase their favourability of that service.

If local municipalities could "pay guys to come and do beautiful tiling, or well-known artists", or host community competitions where people submit creative ideas to add character to the community, HCDE3 believes available funding can be utilised effectively to foster the level of innovation South African PT desperately needs (HCDE3:I27). "[T]rain stations that feature local art" really "makes it feel like a community space, and is actually nice to be in", very likely affecting people's perceptions of that PT service (HCDE3:I24). Giving PT infrastructure a modern look is also "really attractive to young people in certain demographics" and installing Wi-Fi in PT spaces "might actually attract people to use PT." (PTE1:I17) Linking to with this, universal design standards function with the vision of providing a transport environment where accessibility solutions benefit all commuters as integrated members of society, not just those with disabilities (Story et al., 1998; Aarhaug & Elvebakk, 2015). A PT system that is poorly designed may actually *create* a disability in a passenger who does not follow the norms of a social group. For instance, passengers travelling with heavy baggage and prams can be classified as 'disabled' during their travel journey (Shakespeare, 2006).

Thus, if local transport authorities can derive transport innovation from the universal desires, needs and feedback of commuters, this innovation could become the foundation of successful, desirable and sustainable PT development. By creating things that people desire, businesses can successfully offer the level of innovation they desire and, as a result, experience the growth they are aiming to achieve (HCDE1:I20), and if "desire" is equal to "value" (HCDE1:I20), people will be willing to pay for it more (HCDE1:I20; PTE3:I27). Thus, as concluded by the argument in ST2 ('Harnessing innovation in transportation and why it is lacking'), making an "investment in infrastructure that recognises human desires" (HCDE3:I24) may in fact offer transport businesses the increased patronage and growth they desire.

4.1.5.1.2 Initial list of public transport design principles

4.1.5.1.2.1 Initial PT Principle 1: Prioritise safe, reliable and affordable transport services

While literature from Nielsen et al. (2005) and Mees (2010) advise planning for "speed, consistency and reliability", data collected from South African PT experts have indicated otherwise. ST2 of this study highlighted what experts believed to be the key needs of South African commuters. In order to determine the importance of each need, needs were rated first on the number of experts who referred to it (maximum six experts), followed by the number of responses relating to that need. Table 10 illustrates this rating of needs, along with a column with literature support for each need. According to this rating, Gauteng PT experts prioritise safe and secure, reliable and punctual and affordable PT services.

PTE2 believes "access to safe, affordable and reliable transport" is currently the highest priority in South Africa's PT provision (PTE2:I23). All three PT experts, as well as HCDE3 (HCDE3:I17), emphasised safety and security as one of the most important commuter needs, both at ranks and in PT vehicles (PTE3:I7) so that commuters can access transport services safely (PTE2:I4). It is noted that a large portion of middle-class people "will not use PT because of safety" (PTE1:I5). PTE1 says that "affordability is quite a huge factor in PT, because PT actually transports the majority of workers" (PTE1:I4), while PTE3 says that affordability is commuters' "number 1" need – commuters "will sacrifice a lot of luxury, but the bus should be affordable: that's very important for the passengers" (PTE3:I7). These views are reinforced by PTE2, claiming that if a transport service is "affordable and safe, then people would *want* to use it" (PTE2:I23).

PTE1 (PTE1:I4), PTE2 and HCDE3 (HCDE3:I17) state that the reliability and punctuality of transport services are important, especially to transport service providers as a reliable service develops into a sustainable service (PTE2:I23). This need strongly relates to an omission of vehicle breakdowns (PTE3:I7), which commuters require as it improves the reliability of the service.

Table 10: Rating South African commuter travel needs based on frequency of expert responses

Rating	Commuter needs	Supporting insights	Supporting literature
1	Safety and security	PTE1:I5 PTE2:I4 PTE3:I7 HCDE3:I17	Poor service quality is characterised by issues like lack of safety and security… (Shaw, 2006; Barrett, 2004). Investigation results from Lombard and Hugo (2002) indicate that a two-thirds of commuters did not make use of rail services due to the lack of safety and reliability offered by the service.
1	Reliability and punctuality	PTE1:I4 PTE2:I23 PTE3:I7 HCDE3:I17	A key challenge that must be addressed in South Africa is the disparity in the provision of affordable, reliable PT services for commuters in the lower-income range who are dependent on the system to travel and earn a living (Mthimkulu, 2015). The level of service quality offered by PT services (including safety, reliability and convenience considerations) seems to have a strong influence on a commuter's travel mode selection (Aarhaug & Elvebakk, 2015).
2	Affordability	PTE1:I4 PTE2:I23 PTE3:I7	Poor service quality is characterised by issues like… expensive service charges (Shaw, 2006; Barrett, 2004). Commuters had no alternative to their original mode of transport due to the alternative modes being too expensive (Lombard & Hugo, 2002).
3	Accessibility	PTE1:I4; PTE1:I5 PTE2:I23; PTE2:I4	Some commuters are also not able to access regular BRT or MBT services (Barrett, 2004). It seems the degree of accessibility that passengers have to travel services and transport

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			infrastructure is a pertinent issue that engineers and transport professionals are attempting to optimise. This is considering that an elevated number of people will find it challenging to use PT services in the time to come (Samfunnsspleilet ne, 2004).
3	Convenience: Connectivity, ease of transfers and ease of interoperability	PTE1:I4 PTE2:I23	Shaw (2006) believes these issues clearly indicate a transport environment that lacks in conductivity to make transfers simpler and safer Commuters had no alternative to their original mode of transport due to the alternative modes being too expensive, having to walk too far to get to the mode and being inconvenienced by extensive waiting times (Lombard & Hugo, 2002).
4	Availability	PTE1:I4; PTE1:I5	Poor service quality is characterised by issues like… rail transport either not being available or too far away to access (Shaw, 2006; Barrett, 2004). The decision to alter travel behaviour and avoid peak-time traffic is also strongly affected by the availability of travel information (Ben-Elia & Ettema, 2011; Ben-Elia & Shiftan, 2010; Ampt, 2004).
4	PT vehicle characteristics: amenities, clean vehicle, available luggage space	PTE3:I7	These respondents plead that smoking is prohibited on PT services (Lombard & Hugo, 2002). On board trains and buses, it is suggested that security cameras are installed, and official conductors hired to check tickets, while also providing a hotline for emergency situations (Lombard & Hugo, 2002).

| 4 | Travel time | PTE3:I7 | Notably, the use of PT and NMT become a more attractive travel choice as travel time decreases (Ettema & Verhoef, 2006).

Most population growth in low-income residential areas takes place on the perimeter of the PT network, meaning citizens living far from PT hubs are faced with increased travel time and travel costs (TDA, 2014; Boraine et al., 2006). |
| 4 | Maintenance of PT infrastructure | HCDE3:I17 | Commuters are dissatisfied with MBT services because of the lack of roadworthiness of their service vehicles (Shaw, 2006). |

4.1.5.1.2.2 Initial PT Principle 2: Provide access to as many commuters as possible to use PT services

With a total of four references (see Table 10), accessibility was seen by South African PT experts as the next commuter need to prioritise. PTE2's explains that "if you're giving people access, that means you've thought about and designed that there's access for everybody" (PTE2:I23). PTE1 emphasises that commuters require the shortest distance between their home and where they access PT services (PTE1:I4).

Furthermore, access to PT services also means being universally accessible so that it caters for all types of PT users, including those with disabilities (Nielsen & Lange, 2008). PTE1 supports this requirement, claiming the need of accessibility also strongly relates to considering the needs of the disabled community (PTE1:I5), who often have limited access to PT due to their disabilities. All-encompassing, PT services should be designed and offered as attractive, inclusive services that consider all types of users. In areas where a low demand for PT exists, alternative transport solutions must be provided so that people have access to other hubs and nodes in the PT network (Nielsen & Lange, 2008).

4.1.5.1.2.3 Initial PT principle 3: Convenience: connectivity, ease of transfers and ease of interoperability

As can be seen in Table 10, two PT experts referred to the importance of PT services being convenient by offering connectivity in the transport network, simple transfers between modes and the ability to use several PT modes with ease. PTE2 states that "*ease of interoperability* within an *integrated* transport network" is an equal priority to safe, affordable and reliable transport, as commuters would prefer to use multiple modes to travel where they want to go and "will have no problems paying for that as long as they know it *works*, but right now it doesn't *exist*." (PTE2:I23). This principle also relates to the need for an integrated payment system and electronic PT cards that can be used on "any particular system that you

actually come across" (PTE1:I4), so that payments between different PT modes are integrated and thus made more convenient for multi-modal commuters, thus promoting ease of interoperability.

For instance, Singapore uses an integrated ticketing system called the EZ-link smart card, which is cashless and allows commuters to seamlessly travel and pay for different types of trips (Ibrahim, 2003), thus addressing issues relating to theft and not paying for trips while also enhancing payment convenience (Fang & Zimmerman, 2015). This decision is helpful in the sense that it promotes better modal regulation, provides PT with priority over automobiles and provides commuters with increased convenience as only one ticket needs to be bought (Shaw, 2006; Nielsen, Nelson & Mulley, 2015; Menckhoff, 2005).

4.1.5.1.2.4 Initial PT Principle 4: Prioritise network integration

PTE2 states that "*ease of interoperability* within an *integrated* transport network" is an equal priority to safe, affordable and reliable transport (PTE2:I23), while Naude, Jones and Louw (2005) mention integration as one of the urban design principles used to develop design guidelines for PT facilities in Cape Town, South Africa. Shaw (2006) believes commuter dissatisfaction with PT service provision in South Africa is explained by the inadequate quality of services and the lack of modal integration, stating current transport issues in South Africa highlight the lack of integration of the rail with its feeder modes. Formal and informal transport modes continue to compete without the thought of integrating their services, failing to present more effective standards of service delivery. This emphasises the need for formal modes to introduce and follow performance objectives for their transport service delivery (Shaw, 2006).

There seems to almost be a deliberate attempt by various modes to avoid modal integration, likely because of the complications it would present for their payment systems and operational freedom (Brand South Africa, 2015). This lack of integration is also believed to result from an overall lack of strategic and holistic thinking on how to interlace multiple modes of transport fairly and efficiently into a single, cooperative network (Van der Westhuizen, 2007; Mostert, 2011). Land Transport Authority (1996) says PT integration in many developing cities remains a challenge due to a lack of synergistic leadership between authorities, all needing to serve a role that enables specific network components to become more synchronised. This type of collaboration should ideally be linked to a source of funding and an authority that can approve of integration plans so that these plans can be put into action.

PTE3 supports the above statements, explaining that planning from the transport authorities' side is complicating and prohibiting network integration. The inability to address commuter requirements is believed to result from a lack of "integrated planning offices at local municipality level", even though such planning or direction to implement integration plans is a requirement within the IPTNPs progress. This lack of planning is believed to be the missing link between commuters *stating* their needs and desires and those

requests actually being *implemented* – in fact, PTE3 believes integration plans will not exist without these planning offices (PTE3:I30).

Schalekamp et al. (2007) believes media and management structures of paratransit services have the potential to become far simpler and more efficient when these modes collaborate in a single, complementary transport system. In Singapore's PT context, Ibrahim (2003) found that network integration serves the enhanced provision of travel information, journey planners and trip booking systems, where travel information provided offers real-time information on mode locations. Passengers also can pay for their trips with or without cash thanks to the provision of cashless fare systems, thus making PT more attractive due to enhanced convenience (Ibrahim, 2003).

4.1.5.1.2.5 Initial PT Principle 5: Aligning institutional priorities with PT development

National policies should support and complement transportation policies (Colin Buchanan and Partners, 2003; ECMT, 2002), implying that South African governments and authorities should align their national priorities with the development of PT. However, as PTE3 pointed out, with "the upcoming local elections, you will have a stoppage of [PT] services for certain individuals to further their political aims" so that leaders are better recognised (PTE3:I5). This poses the question: is the South African government *really* prioritising the development of its PT system to serve the people and provide a good transport service, or is PT only developed to serve their own plans or political agendas?

For example, scholars investigating the financial aspects of the Gautrain project discovered major flaws in its cost-benefit analysis, noticing that the consumption of public funds exceeded the benefits the systems would offer to the Province - this is likely because of the enormous cost overrun in the project (Van der Westhuizen, 2007). Thomas (2016) believes that the only reason a project with so many fundamental flaws would go ahead is because the government at the time desired to leave behind a legacy, this while the need to provide safer, more reliable transport to dependent citizens was a far greater national priority. HCDE2 supports the above view, explaining that municipalities effectively applying public consultation "don't always last that long" due to the ulterior motives, differing priorities and selfish political agendas of those who come into power at that time (HCDE2:I24).

A lack of strong, synergistic and holistic leadership is the primary reason behind the lack of modal integration, policy/plan implementation and meeting commuter needs in South Africa (Van der Westhuizen, 2007; Mostert, 2011; Poliak et al., 2017; Land Transport Authority, 1996; PTE3:I12). Thus, HCDE3 believes the "mindset changes of people in power" is a key issue that is going to come to light (HCDE2:I40). The work of Nielsen, Nelson and Mulley (2005) elaborate on this, stating that "institutional factors may strongly affect the opportunities for overall planning of network." Both PTE2 and PTE3 claim that political will is the primary means of addressing unmet commuter needs in South Africa (PTE2:I8),

suggesting an overall lack of strategic and holistic thinking on how to interlace multiple modes of transport fairly and efficiently into a single, cooperative network is a root cause for a lack of modal integration (Van der Westhuizen, 2007; Mostert, 2011).

In fact, one of the main steps of modal integration is *organisational* integration, involving assigning responsibility to a public authority to define, coordinate and organise the integration of transport services (Pucher & Kurth, 1995; Poliak et al., 2014), the lack thereof elaborating why modal integration has not yet commenced in South Africa. As a result, failure to implement suggested PT initiatives, regulations and policies (which Poliak et al. (2017) says is caused by a lack of leadership on that part) also limits the objective of integrating these transport systems (Department of Transport, 2021; Turok & Watson, 2001).

Schoeman (2014) asserts that the priority of development should be aimed at encouraging strong leadership and active citizenry to strengthen commuter's accountability, while Thomas (2016) claims it will be simpler to determine the necessary transport needs and policies by constructing a more collaborative, democratic process. Interpolating this argument, HCDE1 says if all parties working together know what success looks like for the *entire unit*, they can aim to create a system that "allows everybody to know what it is that they need to do" so they can *all* achieve success (HCDE1:I31). All stakeholders in South African transport provision need to serve a role that enables specific network components to become more synchronised and ideally be linked to a source of funding and an authority that can approve of integration plans so that these plans can be put into action (Land Transport Authority, 1996). Mthimkulu (2017) believes that an effective, well-operated and sophisticated PT systems can be offered only once the political will of government officials and national leaders is aligned with suggested plans and policies.

4.1.5.1.2.6 Initial PT principle 6: Developing local management structures for PT operations

Thomas (2016) believes South Africa can achieve the same level of inclusive transport management as developed countries by establishing local transport authorities as greater means of modal support and regulation, allowing transport operations to be coordinated locally so the travel needs of citizens can be met more specifically. Other scholars also argued that a form of "regional structure" for transport operations is imperative (Colin Buchanan & Partners, 2003; ECMT, 2002) and that a need exists to regulate the actions of private operators, allowing operator behaviour to be managed locally at a city level (ITDP, 2004).

Furthermore, scholars argue that transport systems must also be able to "adapt dynamically" to new commuter needs and the economic paradigm of the PT system (Nielsen & Lange, 2008), while the executive power to manage a competitive transport environment must be assigned to local authorities (Chen et al., 2016). In order to offer South African rail corridors with the innovation and revitalisation it so direly requires, it is recommended that rail networks in cities are isolated from national rail companies and that

local transport authorities are established to promote fairness and effectiveness in the provision of rail transport. A pro-active approach to transport also needs local governments to intervene in the provision of infrastructure, regulation of private operators and monitoring service provision (Shaw, 2006).

Therefore, global scholars have emphasised the need for transport operations to be managed on a local level within independent regions or municipalities to serve the network's efficiency and development – the PT experts interviewed in Phase 1 agree. PTE3 recommends the establishment of municipal integrated PT control centres to promote network integration in South Africa, existing on a smaller scale and on a centralised basis and eliminating human intervention by electronically (and thus automatically) monitoring, managing and communicating with PT vehicles. Herein, busses and taxis feed into rail transport, meaning their timings should be synchronised so that feeder services leave punctually and arrive at the train station just before the train leaves. In the event of exceptions such as bus breakdowns or late arrivals, drivers should be able to communicate with the control centre to inform them of the exception so that the rail service can be held back, and commuters are swiftly informed of any schedule changes (PTE3:I39).

In relation to this, PTE2 explains that setting up a "transport authority that's independent of the government changes" is one way of countering fragmented transport provision, and is supported by Mostert (2011) who advises the instantiation of a special purpose transport agency (with a holistic perspective on PT and carrying a reputation of transport improvement) to monitor and manage the movement of all formal transport service operators. Therefore, this initial PT principle relates to managing transport operations locally but also setting up local transport authorities that are independent of government changes that can monitor and manage all formal transport service providers.

4.1.5.1.2.7 Initial PT principle 7: Define the roles and function of every mode

This principle was suggested by the work of Naude, Jones and Louw (2005), who recommend specifying the "function and role" of each transport mode as a PT principle. Every mode in an urban transport network has a very specific role to play, serving different travel corridors and passenger volumes (Department of Transport, 1998). In order for authorities to upgrade and optimise transport systems, scholars recommend balancing the network by introducing high-capacity BRT services on major arterials, in turn constructing an efficient trunk-and-feeder system in cities where automobiles and MBTs used to dominate (ITDP, 2004).

Interestingly, the objectives held by the Gautrain rapid transport system focussed only on shifting private vehicles from the road to the rail (Oxford, 2013), without carefully considering how its rail and bus services would integrate with the transport strategies and plans of nearby municipalities (Thomas, 2016); in fact, integrating BRT with the rail is a vitally important step to create a successful, seamless PT system (Seoul Development Institute, 2003). This lack of insight arguably resulted from a fragmented sense of PT

development, failing to assign each mode in the network with a specific role and function, and maintaining the role of each mode in the network.

HCDE2 explains that the issue with South African rail and bus services is that "the taxi industry has sabotaged them totally", resulting in competition between the sectors – this is why we "need to solve the taxi industry issue." (HCDE2:I43) "The reason there is so much [taxi] violence is because there's so much competition", as "every other form of transport is a threat to the existing industry". Thus, "when new forms of transport emerge", "they attack those new forms of transport". This "kind of lawlessness which is there in general" is "is not conducive to a good sector." (HCDE2:I20) Shaw (2006) adds that only cities practising proper control over the enforcement and regulation of transport service operators have found success in transport infrastructure upgrades. Thus, the South African government's inability to effectively regulate the detrimental competitive practises of these informal modes (primarily MBTs) has been a reason why South Africa has struggled to develop PT systems and encourage increased ridership (Shaw, 2006).

With the above in mind, it is clear that one reason why South Africa has struggled to develop its PT service provision is the failure to assign each transport mode with a particular role and function in the transport system (namely, its contribution) and enforce these assignments. This is likely because the South African DoT has allowed some operators to become too developed, to the extent that they cannot reassign its operations because its operations "have become pivotal to the success for PT service provision." (PTE2:I13) Therefore, a need exists to reform South Africa's system such that each mode (namely rail, BRT, MBTs, etc.) has a specific, defined role to play in its successful operation, while enforcing this assigned function, regardless, so that the system can function efficiently.

4.1.5.1.2.8 Initial PT principle 8: Promote collaboration and interaction between various stakeholders

It should be noted that the during the design of the Gautrain raid transport system, the Gauteng Province chose to manage and implement the project without support from local municipal governments usually involved in PT infrastructure planning, and without consulting the public in the design process. Furthermore, the project's execution was continued without considering other more affordable transport alternatives like BRT (Thomas, 2016). PT integration in many developing cities remains a challenge due to a lack of synergistic leadership between authorities, which all need to serve a role that enables specific network components to become more synchronised (Land Transport Authority, 1996). Therefore, a huge problem seems to exist with a lack of collaboration and interaction between various transport stakeholders, including commuters, service providers and local government.

Pillay (2001) claims that discussion between stakeholders such as transport planners, engineers, urban designers and politicians would be the most effective in generating feasible alternatives for a sustainable, efficient PT system. Zellner (2008) supports this view, believing scientists, policy makers and citizens should

be involved in decisions to redirect transport policies to integrated network standards (Zellner, 2008). Furthermore, PTE2 recommends that a team of policymakers should include an individual or team with human-centric skills, such as a psychologist or HCD specialist. This component of the design team can talk to customers, listen to their needs and understand what is important to them, while the other professionals focus on the transport design. That way, the core needs of the human being is being considered in the design process, while systems-based experts can apply *their* expertise to the project of interest (PTE2:I26).

Lara et al. (2016) found that in order to reach smart city standards, it is important to work together with citizens and institutions who are knowledgeable of the history, culture and probable future of the city, in order to properly design for its unique characteristics. A smart city was defined as "a community that systematically promotes the overall wellbeing for all of its members, and flexible enough to proactively and sustainably become an increasingly better place to live, work and play" (Lara et al., 2016; p9). The human infrastructure domain of a smart city can be enhanced by involving citizens in the joint design and implementation of services within the city, through encouraging and allowing citizens to participate in the construction of infrastructure as well as gathering and utilising continual feedback on its effectiveness in meeting their needs (Rizzo, et al. 2013).

Leaders of smart cities must discover means to connect with people such that they create a shared vision for the city they wish to live in (Lara et al., 2016) and encourage a lifestyle that aligns with the values and culture of its people (Ballas, 2013). To make a city and community "smart", all initiatives must comprise of an iterative, user-centric process where the community is involved in design and development (Lara et al., 2016), and all innovative solutions (including technology, infrastructure and transportation) are offered with the central goal of serving the needs of the city and its people, ensuring the city is both highly independent and economically sustainable (Yigitcanlar et al., 2016).

Experts interviewed in Phase 1 are in agreement with the above. HCDE2 believes elevated customer satisfaction in South African transport can be offered by building in stakeholder's consultation into the PT design model (HCDE2:I42), where successful consultation with the taxi industry includes ", from the planning stage, both the drivers as well as the commuters" (HCDE2:I13). HCDE3 believes diverse, facilitated interactions between a mix of people are the key to unlocking the solutions dormant in people's minds (HCDE3:I2), while a lack of knowledge and experience (which could be gained from another stakeholder during interactions) is believed by PTE2 to be a reason why authorities fail to implement agreed-upon plans and policies in the transport sector (PTE2:I12). HCDE2 recommends that South African transport authorities "set up negotiating forums, some sort of space where the authorities and the people they are making decisions on behalf of have a regular engagement,", where monthly meetings are proposed (HCDE2:I32).

Notably, HCDE2 believes that, sometimes, the reason authorities don't consult with the public on proposed designs or plans is "because they don't know how to do it" (HCDE2:I35). Therefore, considering the above, incorporating stakeholder consultation into South Africa's PT model is *crucial* for its current development, allowing a spectrum of different stakeholders (including commuters, scientists, authorities and psychologists) to contribute their unique perspectives to designing a PT system with the central goal of serving the needs of the city and its people (Pillay, 2001; Zellner, 2008; PTE2; Yigitcanlar et al., 2016). By consulting with transport stakeholders on a regular basis (monthly, as HCDE2 proposes (HCDE2:I32)) and building such consultation into its PT design model, Gauteng can move closer to smart city standards and become more user-centric, thus becoming more independent and economically sustainable (Yigitcanlar et al., 2016).

4.2 Phase 2 – Quantitative, correlation-based surveys

4.2.1 Correlation analysis

Once it is found that two variables are indeed related, a statistical strategy known as regression can be applied to use the value of one variable to estimate the value of the other, thus utilised to test the dependability and legitimacy of values measured in the field (Price et al., 2017). After a sufficient quantity of data is collected, the next stage of research is to quantify the correlation and covariation (i.e. the variation in correlation) between the variables of interest (Almeida, Queirós & Faria, 2017). This correlation is generally illustrated using a scatterplot diagram, which plots data points resulting from two variables on a two-dimensional *x-y* axis. If the two variables are related, the scatterplot can indicate either a *positive* relationship, where the increased value of one variable causes an increased value in the other, or a *negative* relationship, where the increased value of one variable causes a reduced value in the other (Price et al., 2017).

Through a sequential statistical analysis, a factor known as *r* (the Pearson Correlation Coefficient) results, describing quantitatively how strongly two variables are related (Cooper & Schindler, 2001; Almeida, Queirós & Faria, 2017). The value of r ranges from -1 (the strongest *negative* relationship illustrated as a *negative*-gradient straight line) to +1 (the strongest *positive* relationship illustrated as a *positive*-gradient straight line); *r* = 0 indicates there is no correlation between these variables, illustrated as a cloud of data points on the scatterplot diagram.

Once enough surveys are completed, summarise and tabulate the answers into computer software and remain aware of any trends or patterns that arise. Process the data obtained using a selected statistical method and, once the statistics have emerged, interpret what the findings imply to the study of interest. A more in-depth discussion on data analysis and synthesis is provided in the data analysis section of this study (Almeida, Queirós & Faria, 2017).

4.2.2 Quantitative surveys

Bhatia (2018) proposes two main stages to the analysis of survey data: data *preparation* and then data *analysis*. As a result, the information in this section is discussed based on these two stages.

4.2.2.1 *Stage 1: Data preparation*

The purpose of data preparation is to transform raw survey data into a useful and workable that can be analysed. This stage is broken up into three main steps. Firstly, data is *validated* to check whether it was collected according to the research design chosen for the study (Bhatia, 2018). Herein, the following is checked:

1. **Fraud** – were all participants interviewed and are responses real, as opposed to fake?
2. **Screening** – were participants selected correctly according to the inclusion- and exclusion criteria?
3. **Procedure** – did the researcher follow the data collection procedure designed?
4. **Completeness** – were all questions answered by the participant, and if not, why and what is to be done?

Next, the datasets are checked for *errors* by searching for data outliers and removing data that may influence the reliability of the results by editing the raw data. Data is then *coded* by grouping similar responses and quantifying these answers to prepare for data analysis. Note that it is simpler to work with age brackets as opposed to a range of individual ages, which may complicate data analysis and be more tedious to work with (Bhatia, 2018). Data is then prepared and ready to be analysed.

4.2.2.2 *Stage 2: Data analysis*

Bhatia (2018) specifies that two levels of data analysis should be applied, namely *descriptive* statistics followed by *inferential* statistics. Afterwards, survey results are *presented* through numerical, graphical or visual means (SurveyMonkey, 2021b; Amaresan, 2019).

4.2.2.2.1 Level 1 – Descriptive statistics

Descriptive statistics provide a way for researchers to summarise and discover trends in survey data, most useful when a specific numerical sample size is determined, and the study's findings don't need to be generalised to the greater sample population. The first data analysis level includes the mean (dataset average), median (dataset midpoint) and mode (datapoint that recurs the most), as well as the frequency (number of times a datapoint is seen) and range (the highest and lowest data point in the dataset) (Bhatia, 2018). Note that these statistics can be used to analyse interval- and ratio variables (Amaresan, 2019).

These statistics can be determined and applied if data is numerical, such as those resulting from a Likert scale (SurveyMonkey, 2021b). The researcher should choose which descriptive statistics to use based on which best complement their study's research- questions and objectives (Bhatia, 2018). It should be noted that, while helpful to describe data, descriptive data fails to describe the trends resulting from data sets as well as the implications of these relationships (Amaresan, 2019). This is where the second level of data analysis is needed, namely inferential statistics.

4.2.2.2.2 Level 2 - Inferential statistics

Three main forms of analyses are used under the second data analysis level, namely *correlation, regression* and *variance*. Notably, the surveys used in this study make use of *correlation* analysis, which describes how two variables are related, while *regression* both estimates and illustrates how these variables are related. Analysing the *variance* between variables estimates the degree to which two or more subgroups vary (Bhatia, 2018). Note that data resulting from interval- and ratio variables can be analysed using inferential

statistical techniques such as AVOVA analyses, t-tests and correlation analyses, while cross-tabulation can be used to analyse an ordinal dataset (Amaresan, 2019).

4.2.2.2.3 Level 3 – Reporting

Once both stages of statistical analyses are completed, the results of a survey are reported to the respective reader or stakeholder. A part of this reporting process includes the consideration of correlation versus causation to evaluate whether a relationship exists between two variables due to them being *correlated* or one *causing* the other (SurveyMonkey, 2021b).

There are several effective ways to present and report results from a survey analysis. Using *graphs or charts* makes survey results simpler for readers to understand due to data being visually illustrated, while also being more attractive due to the use of colours, graphics and interesting chart types used. Amongst them, graphs like Venn diagrams, scatterplots, line graphs, pie charts, histograms and pictograms are used. Researchers should choose the type of graph that best presents the type of data they wish to display and places emphasis on the key features of this data type (Amaresan, 2019).

Survey results can also be reported in *tables*: an ideal way to present numerical data. Only specific data resulting from the surveys should be selected for presentation based on what the graphic is trying to explain, and can be presented on software like MS Excel and Crosstab. For instance, numerical data can be illustrated using cross-tabulation tables, which illustrate the numerical relationship between specific variables. Participant responses to individual questions are indicated in the respective columns and rows of this table to illustrate how participants responded to each question (Amaresan, 2019).

Graphs, tables and text can be integrated into a *visual representation* of the survey results, with the benefit of appealing to readers who learn in different ways. By doing so, even the earlier stages of the study and survey design can be illustrated, providing space for the research- questions and hypothesis as well as survey questions, methods of analysis and summarised results of the survey to be presented to the stakeholder. Similarly, researchers can further simplify survey results into an *infographic* which combines text and illustrations. This allows survey results to be read and understood quickly by decomposing chunks of text into basic sentences that are interlinked with a particular type of diagram (Amaresan, 2019).

Lastly, and most importantly, a *full report* should be written that includes all the content of the associated study, namely literature, design work, methodology, data collection, data analyses and conclusions that were reached. This report, document or thesis summarising the study at hand is either given to the stakeholder to review privately or given to reviewers to mark at the specified due date of the study (Amaresan, 2019).

4.2.2.3 *Recommended data analysis procedures*

The following two procedures are recommended by SurveyMonkey (2021b) and Amaresan (2019), respectively, to analyse the study's survey data.

4.2.2.3.1 Procedure 1 – SurveyMonkey (2021)

4.2.3 Integrated quantitative data analysis procedure

Since multiple data analysis procedures were provided as literature and two data collection instruments (i.e. correlation studies and quantitative surveys) are used in unison, an integrated quantitative data analysis procedure was developed. This summarises and combines the data analysis considerations for both instruments into a single, clear data analysis procedure for the quantitative surveys, as follows:

1. Select the principal research questions of the study, i.e., those questions the Phase 2 data analysis process aims to answer (SurveyMonkey, 2021b; Amaresan, 2019)
   - Which research questions are of highest priority during the survey data's analysis?
   - Align the context of each survey question to a particular survey question
2. Understand the four measurement levels (namely nominal, ordinal, interval and ratio variables) and select which variable/s is/are most fitting to this study (Amaresan, 2019).
3. Prepare the quantitative data collected (Bhatia, 2018):
   - transform raw survey data into a useful and workable form that can be analysed
   - Summarise and tabulate the survey responses into computer software such as MS Excel or CrossTab, remaining aware of any trends that may arise (Almeida, Queirós & Faria, 2017)
   - Step 1: **validate** data to check that it was collected according to the research design chosen for the study, checking the following:
     - Fraud – were all participants interviewed and are responses real, as opposed to fake?
     - Screening – were participants selected correctly according to the inclusion- and exclusion criteria?
     - Procedure – did the researcher follow the data collection procedure designed?
     - Completeness – were all questions answered by the participant, and if not, why and what is to be done?
   - Step 2: check datasets for **errors**
     - Search for data outliers
     - Remove data that may influence reliability of results
   - Step 3: **code** data
     - Group similar responses
     - quantify these answers to prepare for data analysis
     - It is simpler to work with age brackets as opposed to a range of individual ages

4. Select a sequential statistical method (from research) to analyse the survey data (Amaresan, 2019). For the purpose of this correlation-based quantitative survey, the statistical method used will be *correlation* (Price et al., 2017).

5. **Level 1 of data analysis – Descriptive statistics** (Bhatia, 2018; Amaresan, 2019)

   - Provide a way for researchers to summarise and discover trends in survey data

   - Includes the *mean* (dataset average), *median* (dataset midpoint) and *mode* (datapoint that recurs the most), as well as the *frequency* (number of times a datapoint is seen) and *range* (the highest and lowest data point in the dataset) (Bhatia, 2018)

   - choose which descriptive statistics are used based on which best complement their study's research questions and research objectives (Bhatia, 2018)

   - Note that descriptive data fails to describe the trends resulting from data sets as well as the implications of these relationships - this is where the second level of data analysis is needed (Amaresan, 2019)

6. **Level 2 of data analysis – Inferential statistics** (Bhatia, 2018; Amaresan, 2019)

   - The surveys are using correlation analysis, which describes how to variables are related

   - This is usually illustrated using a scatterplot diagram with a two-dimensional *x-y* axis (Price et al., 2017)

   - Note that the terms 'independent variable' and 'dependent variable' are not used in a correlation study - researchers merely witnesses how the variables behave in their natural habitat and attempt to quantify the relationship between them to inform the acceptance or rejection of the study's hypothesis (Price et al., 2017; Fleetwood, 2020; Almeida, Queirós & Faria, 2017).

   - If survey responses to different survey questions need to be studied separately, filter the results for each specific survey question one at a time (SurveyMonkey, 2021b)

   - This allows a unique trend comparison for different subgroups to be explained to provide greater context and understanding (SurveyMonkey, 2021b)

   - Answers can be presented using cross-tabulation to compare answers relevant to different research questions (SurveyMonkey, 2021b)

   - Results of certain survey questions can provide context or explanation for answers to specific research questions (SurveyMonkey, 2021b)

   - <u>Step 1:</u> Make use of filtering and cross-tabulation to break up, study and present results for specific survey questions separately (Amaresan, 2019; SurveyMonkey, 2021b)

   - <u>Step 2:</u> Plot data on a scatterplot diagram and remain aware of any trends or patterns that arise:

     o *positive* relationship: the increased value of one variable causes an increased value in the other

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- o *negative* relationship: the increased value of one variable causes a reduced value in the other (Price et al., 2017)

- Step 3: Extract the Pearson Correlation Coefficient *r*, describing quantitatively how strongly the two variables studied are related (Cooper & Schindler, 2001; Almeida, Queirós & Faria, 2017)

- Step 4: Quantify the covariation from the statistical analysis, which determines the variation in correlation of the two variables studied (Almeida, Queirós & Faria, 2017).

- Step 5: Evaluate the statistical significance of the results by reviewing the quality of the survey data collected and ensuring the sample population was accurately represented by the study sample (Amaresan, 2019; SurveyMonkey, 2021b)

7. **Level 3 of data analysis – Reporting** (Amaresan, 2019; SurveyMonkey, 2021b)

- Step 1: Account for correlation versus causation
  - o be sure to consider all explanations regarding variable relationships before making a conclusion on what *really* influences a person's behaviour or choices (Amaresan, 2019)
  - o does a relationship exists between two variables due to them being *correlated* or one *causing* the other? (SurveyMonkey, 2021b)
  - o define which variable is most applicable, and why

- Step 2: Report the results (Amaresan, 2019)
  - o **Graphs and charts** make survey results simpler for readers to understand due to data being visually illustrated and are more attractive because of their colours and graphics
    - Choose the type of graph that best presents the type of data you wish to display and places emphasis on the key features of this data type
    - Examples: Venn diagrams, scatterplots, line graphs, pie charts, histograms and pictograms
  - o **Tables** are an ideal way to present numerical data
    - Only specific data resulting from the surveys should be selected for presentation based on what the graphic is trying to explain
    - Present data on software like MS Excel and Crosstab
    - Illustrate numerical data using cross-tabulation tables presenting the relationship between specific variables, wherein rows and columns illustrate certain survey questions and responses
  - o **Visual representations** integrate information from graphs, tables and text, with the benefit of appealing to readers who learn in different ways

- Provides a space for the research- questions and hypothesis as well as survey questions, methods of analysis and summarised results of the survey to be presented to the stakeholder
- Can even summarise earlier stages of the study and survey design
  - **Infographics** combine text and illustrations
    - Further simplifies survey results
    - Decomposes chunks of text into basic sentences that are interlinked with a particular type of diagram
    - Allows survey results to be read and understood quickly
- Step 3: Interpret and report on the study's findings and what they imply about the study, using *r*, the scatterplot form and statistical significance of the results as a reference.
- Step 4: If necessary, compare survey data to historical data of a similar research topic to see if any trends or major changes have been shown over time
- Step 5: Write a full report that includes all the content of the associated study, namely literature, design work, methodology, data collection, data analyses and conclusions that were reached
  - This report, document or thesis summarising the study at hand is given to the stakeholder to review privately
  - Otherwise, it is given to reviewers to mark at the specified due date of the study

4.2.4 Analysis of survey data

A total of 316 survey responses were collected online and in public from adult Gauteng PT users and then inputted manually, question by question, into MS Excel™ by the researcher and DCA. IP surveys were laminated so they could be sanitised and used over and over again, so participants were handed a whiteboard marker and instructed to mark all closed questions with a cross or tick and express themselves in the whitespace provided for open-ended questions.

Each survey comprised of 24 questions that were designed to test the applicability of the initial principles developed from the qualitative interview data, while also aiming to quantify the correlation between the presence of HCD measures in Gauteng PT (**Variable A**) and commuters' satisfaction with and desirability for these services (**Variable B**). The integrated data analysis procedure presented in the section above was used as a guide for the analysis of this data but was not followed strictly as not all considerations resonated with this study. The implications of these results are then discussed in the *Results* chapter of this study, question by question.

After inputting the data for every survey response, a separate spreadsheet was created to summarise the proportions of responses for each question's variables and graphs were produced from the software to

present the data in a simple and visual way. Furthermore, in order to determine the Pearson Correlation Coefficient, r, another spreadsheet was developed that would quantify the relationship between Variable A and Variable B.

4.2.4.1 *Question 1 and 2*

The first two questions are discussed together as they were designed to test **initial PT principle 2 and 7.** In Question 1, participants were asked which transport service they use most often right now for a *long* trip (e.g. travelling from home to the city), *medium* trip (e.g. travelling from home to visit a friend) and *short* trip (e.g. travelling from home to the shop). The results of this question are presented in Table 11. In Question 2, participants were asked which transport service they would prefer or want to use for a long, medium and short trip – the results of this question are presented in Table 12. Please note that some participants marked more than one mode for each trip, as different modes were used in different situations. A comparison was made between Table 11 and Table 12 to establish the difference between commuters' *current* PT use and what their *preference* would be if they had a choice.

Table 11: Results for Question 1

	Walk/cycle	Car/Uber	Train	Taxi	Bus	
Long trip	7	49	5	196	71	328
Medium trip	50	83	7	163	18	321
Short trip	212	37	3	55	6	313
	269	169	15	414	95	962

Table 12: Results for Question 2

	Walk/cycle	Car/Uber	Train	Taxi	Bus	
Long trip	3	114	27	77	94	315
Medium trip	49	135	15	94	21	314
Short trip	181	78	5	36	12	312
	233	327	47	207	127	941

4.2.4.1.1 Long-distance trips

For **long** trips, 196 participants (59.8%) used the taxi, while the remainder mostly use the bus (21.6%) and either their own private vehicle or MAAS like Bolt™ or Uber™ (14.9%). Referring to the customer preferences in Table 12, 114 participants (36.2%) preferred using a private car or MAAS for long trips, followed by 94 bus preferences (29.8%) and then 77 taxi preferences (24.4%).

4.2.4.1.2 Medium-distance trips

For **medium** trips, 163 participants (50.8%) used the taxi, with private cars or MAAS (25.9%) and walking or cycling (15.6%) making up the bulk of the remaining responses. Referring to the customer preferences shown in Table 11, 135 participants (43%) preferred using a private car or MAAS for medium trips, 94 participants (29.9%) preferred using a taxi and 49 participants (15.6%) preferred NMT.

4.2.4.1.3 Short-distance trips

As can be expected, 212 participants (67.7%) made use of NMT like walking or cycling for **short** trips, the remainder of which taxis (17.6%) and private cars or MAAS (11.8%) were utilised. One participant shared that they use their skateboard for medium- and short trips. When considering the sample's transport preferences, 181 participants (58%) preferred NMT for short trips, 78 participants (25%) preferred using a private car or MAAS and 36 participants (11.5%) preferred the taxi.

4.2.4.2 Question 3

Participants were asked which PT service they use most often – this did not test an initial principle. The results of this question are presented in Figure 10. Table 13 illustrates the comparison between the proportions obtained and those required for DCS 1. Given that the study follows a convenience sampling approach, the minor difference between the required and received commuter proportions is acceptable, as all users were located based on what was most convenient and doable for the data collection team.
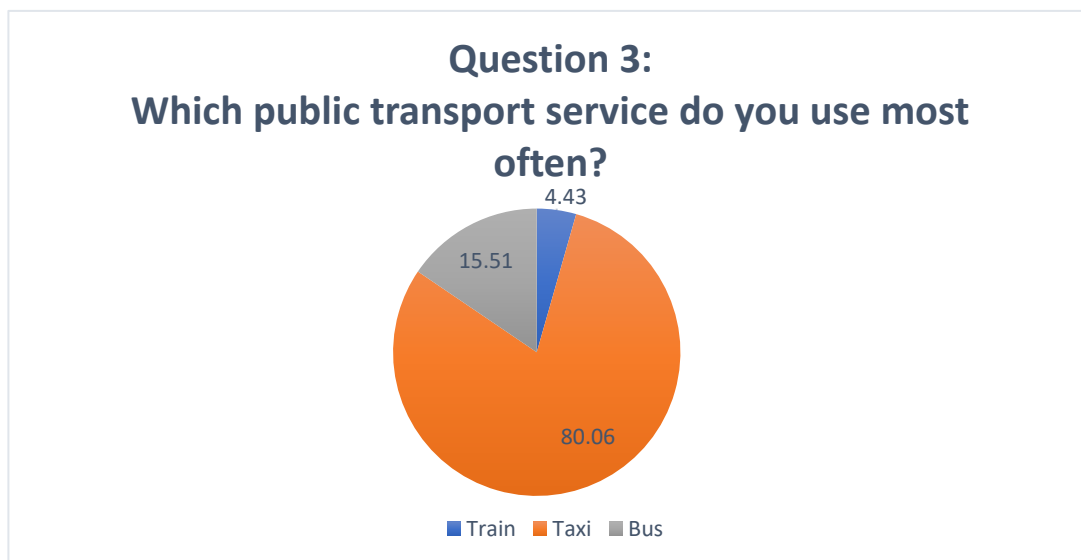

Figure 10: Results for Question 3

Table 13: Comparison between proportion of PT users required and received from IP surveys

Scenario	Train	Taxi	Bus
Proportions required (%)	9.9	82	8.2
Proportions received (%)	4.4	80.1	15.5

4.2.4.3 *Question 4*

Commuters were asked how they feel about the PT service they use most often in order to test **initial HCD Principle 5**. The results of this question are presented in Figure 11. Just over 40% of the sample responded neutrally to this question, 25.5% said they were disappointed with their PT service and 15.6% said they were pleased with their service. The remaining portion of the sample said they were angry (10.5%) and very happy (8.3%) with their PT service. One participant noted that their service was good at times, and bad at others, while another noted that more security was necessary as "you can't control conflict on PT".
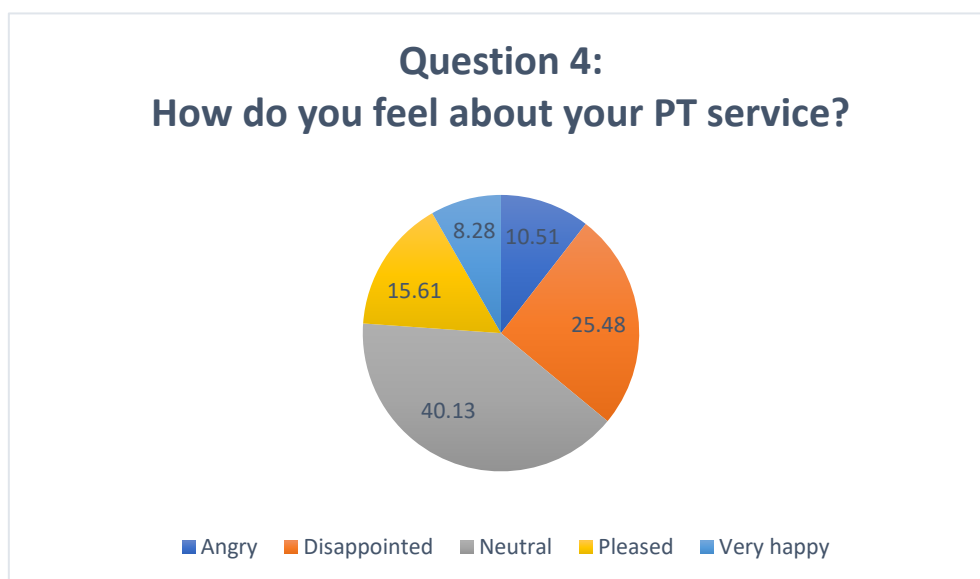

Figure 11: Results for Question 4

4.2.4.4 *Question 5*

Commuters were asked to rate their response to the statement "I enjoy using this public transport service" to test **initial HCD principle 5.** The results of this question are presented in Figure 12. Again, the largest portion of the sample responded neutrally (34.4%), while 23.3% agreed and 20.7% disagreed. The remainder of the sample strongly disagreed (14.7%) and strongly agreed (7%). Two participants noted that they had no other option but to enjoy their PT service. Others stated that taxis take them where they want to go, so they don't mind, buses take longer than taxis and that they want their own car.
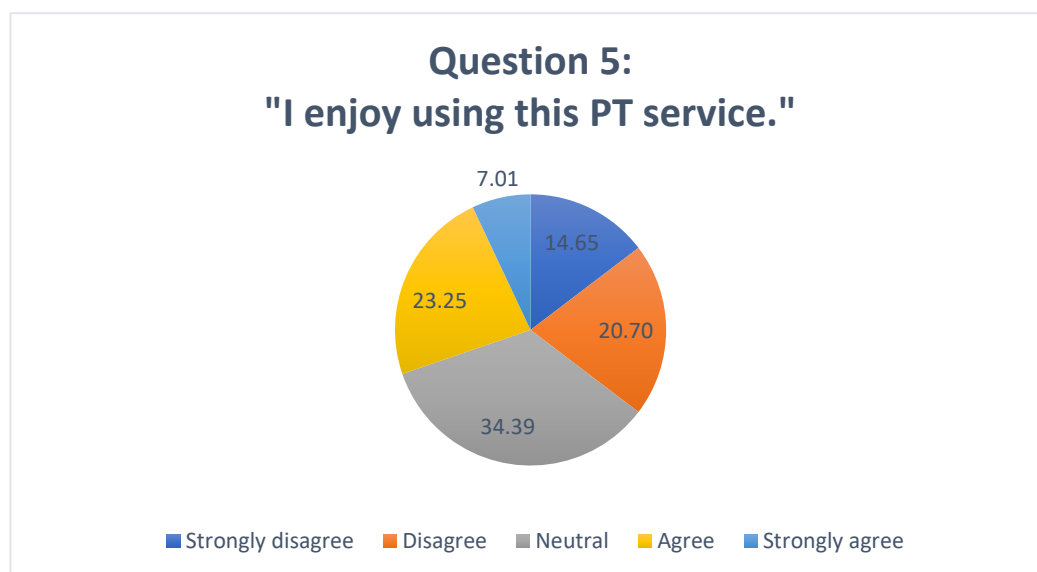
Question 5:
"I enjoy using this PT service."

Figure 12: Results for Question 5

4.2.4.5 *Question 6*

Commuters were then asked to respond to the statement "If this public transport service becomes more expensive, I will pay more to use it" to test **initial HCD principle 5**. The results of this question are presented in Figure 13. The results for this question were distributed fairly evenly, with 24.5% agreeing and disagreeing to this statement, respectively, 23.9% strongly disagreeing and 20.4% responding neutrally. The remainder of the sample (6.7%) strongly agreed. It is interesting to note that 18 participants said they had no choice but to pay more if their PT service became more expensive, stating that they had no other transport alternatives and needed to live with increases in fares. Others stated that they would pay more if it was possibly financially and that their service is already expensive, thus disagreeing to the statement posed.
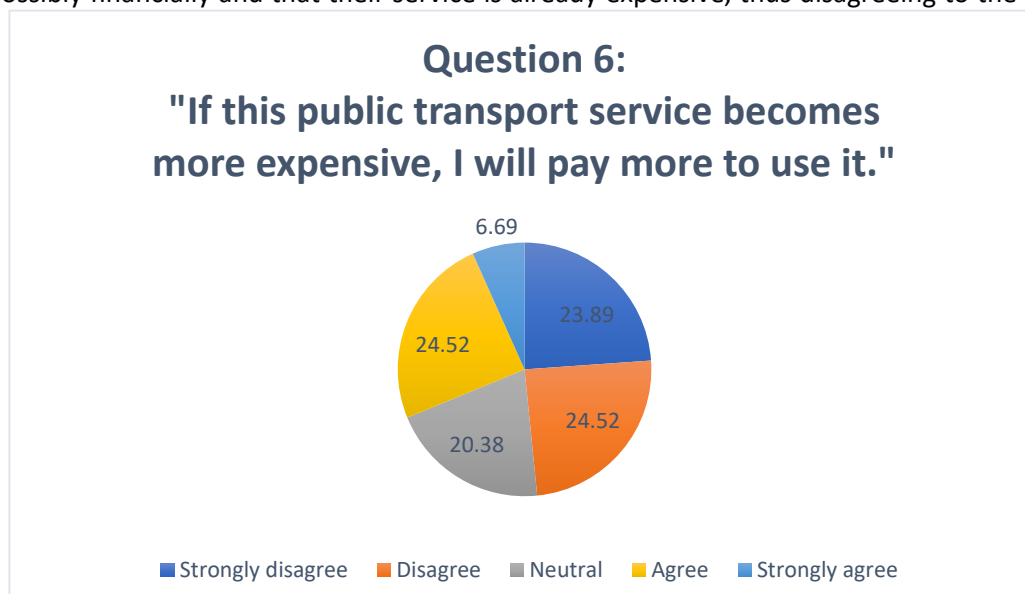
Question 6:
"If this public transport service becomes
more expensive, I will pay more to use it."

Figure 13: Results for Question 6

4.2.4.6 *Question 7*

Participants were asked which four issues (from the eight issues indicated) made them most unhappy with their PT service to test the applicability of **initial PT principle 1, 2 and 3**. The results of this question are presented in Figure 14. Most of the sample found the poor maintenance of their service concerning (22.2%) in addition to the service being unsafe (18.5%) and unreliable (14.6%). A total of 97 participants (11.2%) found their service to be too expensive, finding long travel times (10.2%) and the lack of availability of their service (9.8%) upsetting. The remainder of the sample are unhappy with the payment system of their PT service (6.9%) and find their service difficult to access (6.6%).

One participant commented on the MBT payment system, asking "why do we have to count money for the drivers?", while two participants stated the MBT service is unsafe because taxi drivers don't follow road rules and the door to the vehicle is sometimes broken, respectively. Another participant found overcrowding to be a major issue in the MBT service, stating that customers are packed tightly into taxis (this is casually expected) so that drivers can maximise their earnings. One participant commented on the extremely poor customer service offered by the MBT service, stating that "drivers have a bad attitude and swear at you in many languages."
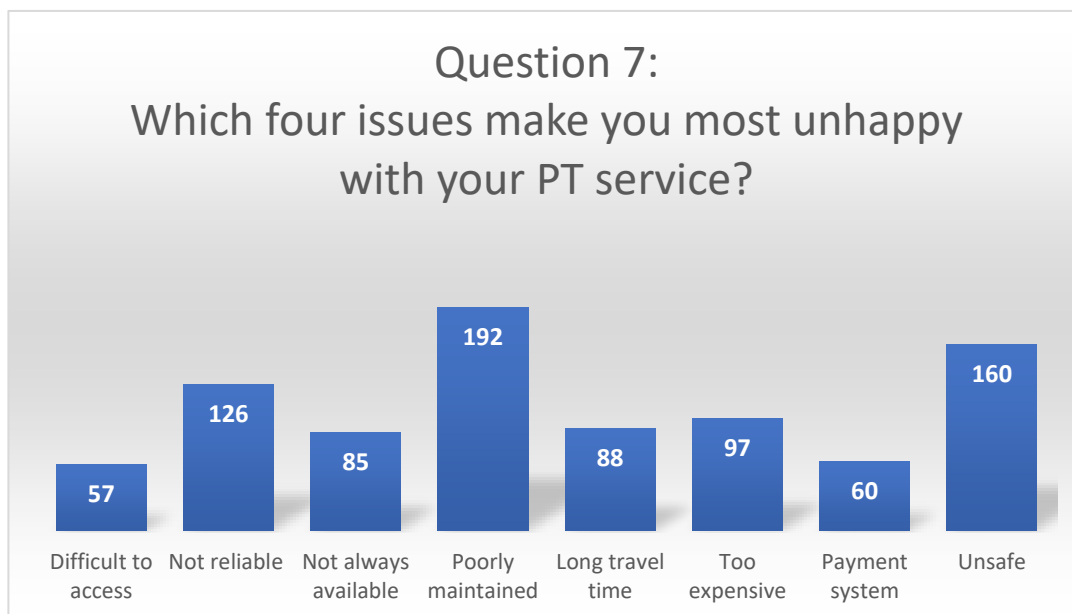

Figure 14: Results for Question 7

4.2.4.7 Question 8

This open-ended question asked participants which changes to their PT service would make their travel journey better to test the applicability of **initial PT principle 1, 2 and 3**. While many participants left this question out, **many** expressed their views and provided 213 helpful insights that they believe could improve their PT experience. Since a massive number of comments were made amongst the 316 surveys, responses with similar themes were colour coded (as shown in Figure 15) and reported on within the same response theme. These response themes are summarised in Table 14 with the number of responses and percentage for each theme. On the right side of the table, comments with a similar nature were grouped together and the frequency thereof was indicated to show what comments each response theme comprised of.

Figure 15: An example of the colour coding used in Question 8 to indicate individual response themes

Table 14: Responses to Question 8 sorted into response themes

Response theme	Number of comments with percentage	Related comments (frequency)
Better roadworthiness and maintenance of vehicles	37 (17.4%)	Well-maintained vehicles/better maintenance/service vehicles/proper vehicles/maintain the train (**19**) Better maintenance/regular servicing of taxis/using taxi in good state (**5**) Newer taxis/buy new taxis/quality vehicles/upgrade standards (**5**) Roadworthy vehicles/taxis falling apart and not roadworthy (**2**) Clean buses/condition of bus/well-maintained bus (**2**) Please wash taxis
Better customer service	29 (13.6%)	Taxi drivers need to be more respectful/ respect their passengers (**9**) More/good customer focus (**8**) Friendlier/more polite drivers (**6**) Drivers must change their attitude/have a good mood (**2**) Professional drivers Taxi drivers need training with respect to customer service Open communication More support [likely from service operators]
Fares, payment and affordability	29 (13.6%)	More affordable/cheaper fares/steady prices/free services (**21**) Better payment system/change taxi payment methods/electronic payment/provide a PT card (**5**) Tell us ahead of time is fares go up To pay for a month of usage Buying a coupon on the bus
Punctuality, reliability and swiftness of service	26 (12.2%)	Service arrives on time/punctuality/want to get to destination on time (**6**) Reliable/more efficient transport services or schedules (**6**)

		Swift, quick services/services should arrive more quickly/not having to wait hours for transport to come/shorter travel time (**4**)
		Time keeping/management (**4**)
		Buses must get to station on time/keep time (**2**)
		More reliable taxis
		Faster bus journey
		Notify users if delays occur
		Long ques
Availability and accessibility	23 (10.8%)	Buses and taxis must be available/more buses and taxis/increased availability/make available 24/7 (**13**)
		Services must be easy to access/more accessible/better access to PT/if I could find taxis easier (**5**)
		Availability in the evening/late at night/more ideal operating hours (**3**)
		Services closer to people
Safety and security	20 (9.4%)	Safety during travel/safe driving/safer (**11**)
		Security deployment (**4**)
		Safety precautions (**2**)
		Safer for pedestrians
		Safety at taxi rank
		Police
		Seatbelts
Comfort and seating space	14 (6.6%)	Solve overloading/more space available in taxi/more space for bags/less people, more space (**7**)
		Comfortable vehicle/comfortable seating plan/new taxis – older ones not comfortable (**6**)
Assorted	14 (6.6%)	I would prefer the buses/buses are better/always improving bus systems (**4**)
		Uber™ (**2**)
		Quantam [taxi] services
		Bring back the trains!
		Bicycle

		Minister of Transport must start doing something about the taxis!
		Take taxis to the government
		Using my own car
		I don't really have a choice
		Sources for information
Behaviour and presence of PT service providers	9 (4.2%)	More careful/responsible driver/follow road rules, laws and speed limits/drive cautiously/keep to a specific lane and abide by it (**7**)
		Need to have taxi conductors/ushers/marshals (**2**)
Entertainment and refreshments	8 (3.8%)	Supermarket nearby
		Television with sport
		Free Wi-Fi
		Refreshments
		Water
		Music
		Art
		Gaming console like an Xbox
Routes, stations and infrastructure	4 (1.9%)	Travel route/drivers must take shorter routes (**2**)
		Create new roads
		Infrastructure
		More pick-up and drop-off stations

4.2.4.8 *Question 9*

Participants were asked what they would like to see in the waiting area of a PT service by selecting any of the eight options provided, to test the applicability of **initial HCD Principle 7.** The results of this question are presented in Figure 16. The greatest portion of the sample desired free Wi-Fi (24.9%), followed by security cameras (21%), comfortable seating (20%) and a travel information board (13.7%). The remainder of the sample wanted to see disabled facilities (8.3%), local artwork (5.3%), a vending machine (4%) and bicycle parking (2.8%).
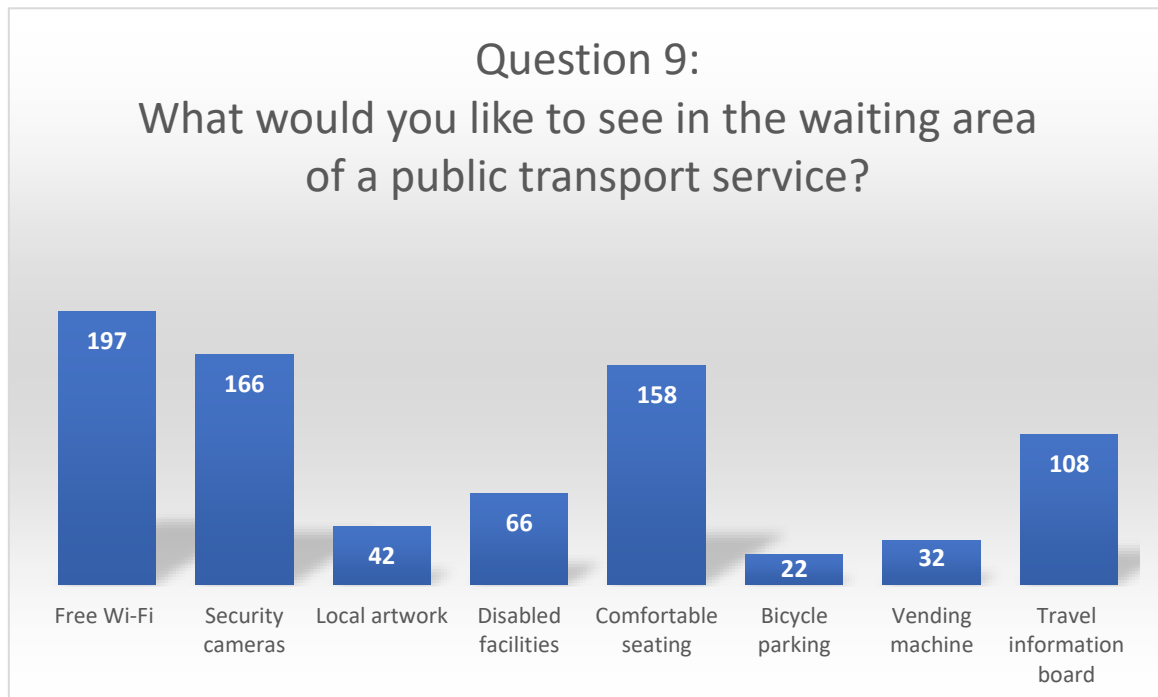
Figure 16: Results for Question 9

4.2.4.9 *Question 10*

Participants were then asked if they would pay more for that PT service if they saw the items they selected in the waiting area, to test **initial HCD Principle 7.** The results of this question are presented in Figure 17. The greatest portion of the sample agreed (34.9%), while 24.7% responded neutrally and 21.5% strongly agreed. The remainder of the sample disagreed (14.4%) and strongly disagreed (4.5%). One participant agreed to the statement if they have enough funds, while another agreed *if* they received a "full service". Conversely, other participants disagreed because they don't have more to spend and aren't happy with the service they receive, respectively.

Question 10:
If you see the items you selected in a waiting room, would you pay more to use this public transport service?

■ Strongly disagree   ■ Disagree   ■ Neutral   ■ Agree   ■ Strongly agree
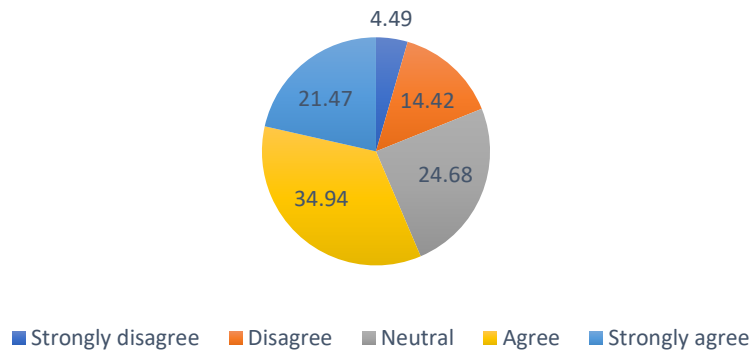
Figure 17: Results for Question 10

4.2.4.10 *Question 11*

To complement Question 9, an open-ended question was posed to participants asking them if there was anything else (besides the options given) that they would like to see in the PT waiting area. Notably, this question was not designed to test any initial principles, but the information therein could add well to the *Discussion* section, or provide handy guidance for the *Recommendations* section, of this study.

Because a great deal of responses were given in this question, a similar approach to Question 8 was taken wherein ideas of a similar nature were colour coded (as shown in Figure 18) and presented together under unique **idea themes**, as shown in Table 15. The number and percentage of responses in each idea theme were indicated in the middle column, while similar ideas were tallied together to give an indication of what the responses in each idea theme related to.

Figure 18: An example of the colour coding done in Question 11 to group ideas into idea themes

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Table 15: Responses to Question 11 sorted into idea themes

Idea theme	Number of comments with percentage	Related comments (frequency)
Safety and security	43 (30.5%)	Security officers/guards/services to make area safe/security all the time (**35**) Security cameras (**3**) Safety for commuters/I want to be safe (**3**) Regular security check-ups Lighting Maximum security at night
Food, drinks and purchases	27 (19.1%)	Free food/light snacks/sweets (**8**) Water fountains/water cooler/water bottles/free water (**4**) Coffee/coffee machine/coffee shop (**4**) Refreshment area (**4**) Vendors/food stalls for people to make money (**3**) Shops nearby please (**3**) Eating area ATM
Entertainment	21 (14.9%)	Entertainment/entertainment area (**6**) Television/football (**5**) Charging station (**2**) An Xbox A social network Books Speakers Free Wi-Fi Smoking area Animals and a garden Newsroom Afrika™
Bathrooms and hygiene	17 (12.1%)	Clean bathrooms/restrooms/toilets with running water (**12**) Cleanliness/taxi should be clean (**3**)

		Cleaning services
		Sanitiser
Comfort and seating	15 (10.6%)	Comfortable seating/benches and chairs/covers on seats/more chairs available (**11**)
		More sheltered areas/shelter at bus stops (**3**)
		Heater
		Order [likely relating to a chaotic public transit area]
Assorted	7 (5%)	Greatly maintained
		Proper signage
		SpeedPoint like Pay2Pay - working with change is admin
		Quality vehicles
		Show the time for the next transport service
		Lost and found - keep my stuff safe please!
		Bicycle rentals
Transport service providers	6 (4.3%)	Laws that can always hold peace between drivers and those using the waiting area
		Reliable taxi marshals
		Friendly bus assistants
		For staff to improve on customer service
		Hosts
		Route navigators
Ques and speed of service	5 (3.5%)	A better queuing system/shorter ques/less lines (3)
		A number of buses must always be available
		Quick service

4.2.4.11 *Question 12*

This question marks the beginning of the back page of the survey. Participants were asked to rate their response to the statement "I would like the opportunity to give my ideas and create the transport service I use." This question was designed to test the applicability of **initial HCD Principle 6, 7 and 8.** The results of this question are presented in Figure 19. Over half of the sample (56.3%) agreed to this statement, just less than a quarter of the sample (23.4%) strongly agreed and 15.8% responded neutrally. The remainder of the sample disagreed (3.2%) and strongly disagreed (1.3%).
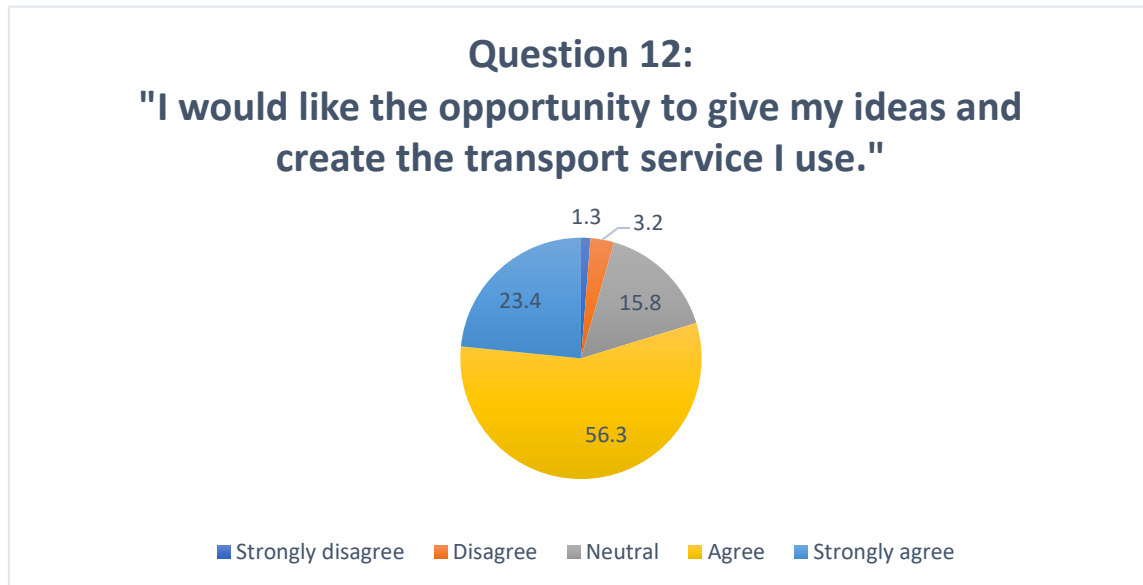
Figure 19: Results for Question 12

4.2.4.12 *Question 13*

Participants were asked to rate their response to the statement "I would be more interested in using public transport if my inputs were used to improve the service I use." This question was designed to test the applicability of **initial HCD Principle 3, 4 and 6**, as well as **initial PT Principle 8.** The results of this question are presented in Figure 20. Just under half of the sample (48.7%) agreed, while the bulk remainder of the sample strongly agreed (34.2%). The remainder of the sample responded neutrally (13.6%), disagreed (2.5%) and strongly disagreed (0.9%).

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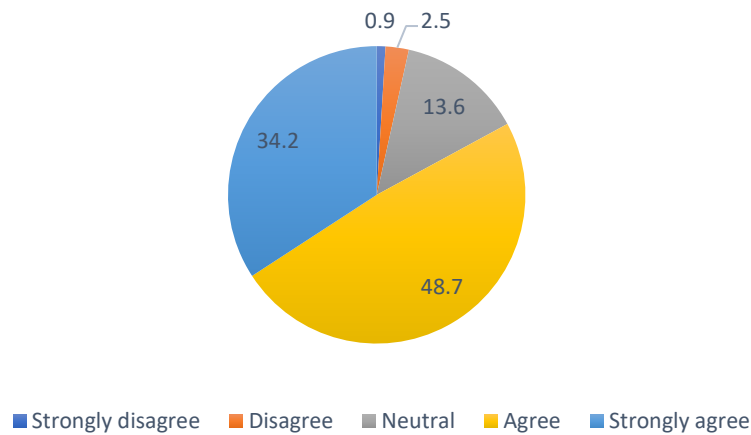
Figure 20: Results for Question 13

4.2.4.13 *Question 14*

Participants were asked to rate their response to the statement "Transport officials make an effort to understand what my biggest problems are and how they can help me." This question was designed to test the applicability of **initial HCD Principle 4**, the results of which are presented in Figure 21. The bulk of the sample agreed to the statement (31%), responded neutrally (20.9%) and disagreed (16.5%). Quite near to these values, the remainder of the sample strongly agreed (16.1%) and strongly disagreed (15.5%). One participant claimed that transport officials are "not doing anything to solve my problems", while another comment mentioned that commuters "need a platform where we [the commuters] can raise our concerns."

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Question 14:
"Transport officials make an effort to understand what my biggest problems are and how they can help me."
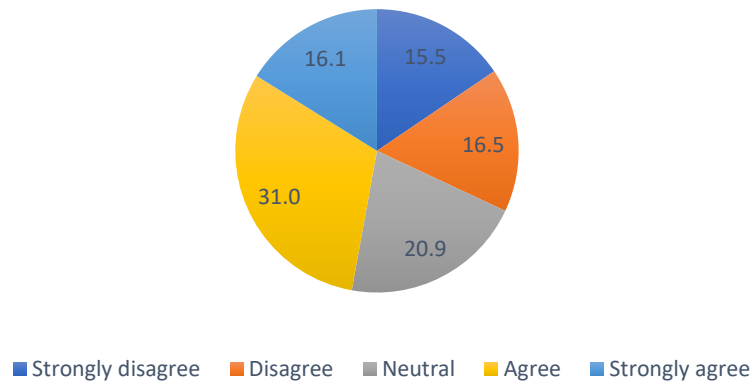
Figure 21: Results for Question 14

4.2.4.14 Question 15

Participants were asked to rate their response to the statement "Transport officials will understand my needs better if they regularly use the same service I use." This question was designed to test the applicability of **initial HCD Principle 1, 4 and 5**, the results of which are presented in Figure 22. The greatest portion of the sample agreed (42.4%) and strongly agreed (30.7%), while the remainder of the sample responded neutrally (16.1%), disagreed (7.6%) and strongly disagreed (3.2%). Two participants disagreed or strongly disagreed to this statement, stating that "taxi drivers are stubborn!" and "they still won't care" even if they use the same service they used, respectively.

Question 15:
"Transport officials will understand my needs better if they regularly use the same service I use."
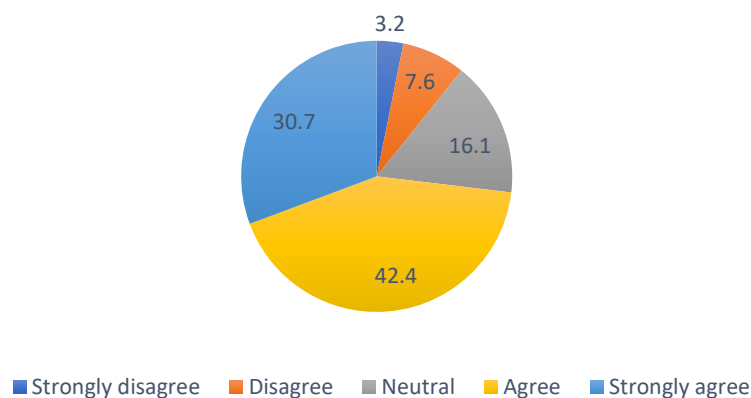
Figure 22: Results for Question 15

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4.2.4.15 *Question 16*

Participants were asked to rate their response to the statement "Some transport decisions are based on politics instead of what people might want." This question was designed to test the applicability of **initial HCD Principle 3**, as well as **initial PT Principle 4, 5 and 6**, the results of which are presented in Figure 23. The bulk of the sample agreed (38.6%) and strongly agreed (30.4%), while the remainder of the sample responded neutrally (14.6%), disagreed (10.8%) and strongly disagreed (5.7%). One participant believes "Everything is about politics!".
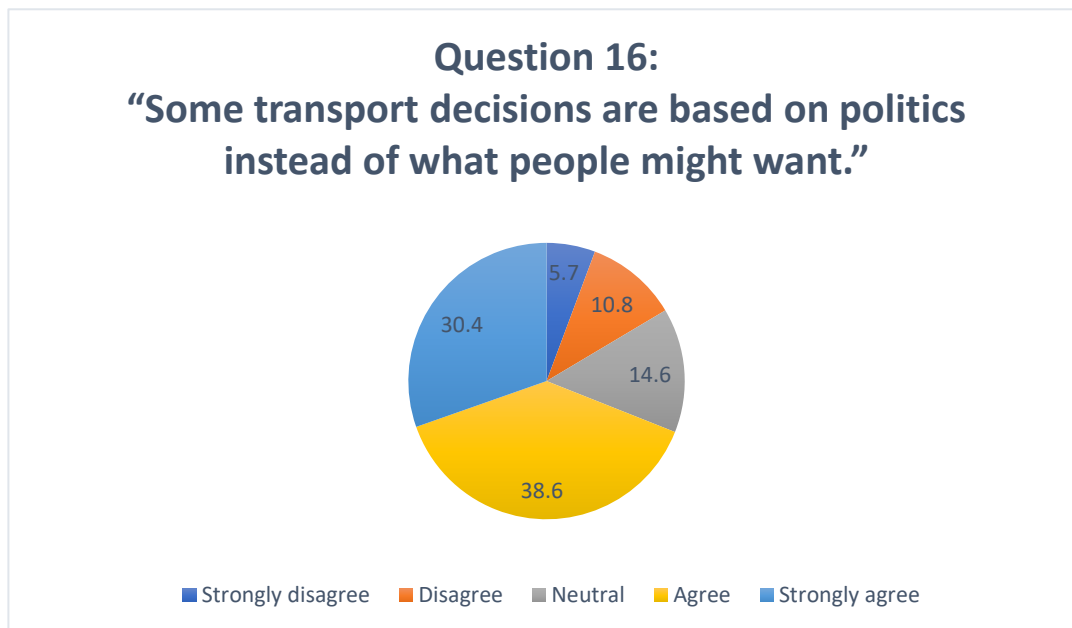
Figure 23: Results for Question 16

4.2.4.16 *Question 17*

Participants were asked to rate their response to the statement "Poor public transport services negatively affect my lifestyle and my job." This question was designed to test the applicability of **initial HCD Principle 2**, the results of which are presented in Figure 24. The largest portion of the sample strongly agreed (44.3%) and agreed (32.6%), while the remainder of the sample responded neutrally (13.3%), disagreed (7%) and strongly disagreed (2.8%)

Figure 24: Results for Question 17

4.2.4.17 *Question 18*

Participants were asked to rate their response to the statement "I would like to know if my public transport service will be late." This question was designed to test the applicability of **initial HCD Principle 3**, as well as **initial PT Principle 4, 5 and 6.** The results of this question are presented in Figure 25. The majority of the sample agreed (44.6%) and strongly agreed (39.6%) to this statement, while the remainder responded neutrally (11.1%), disagreed (3.5%) and strongly disagreed (1.3%) to this statement.
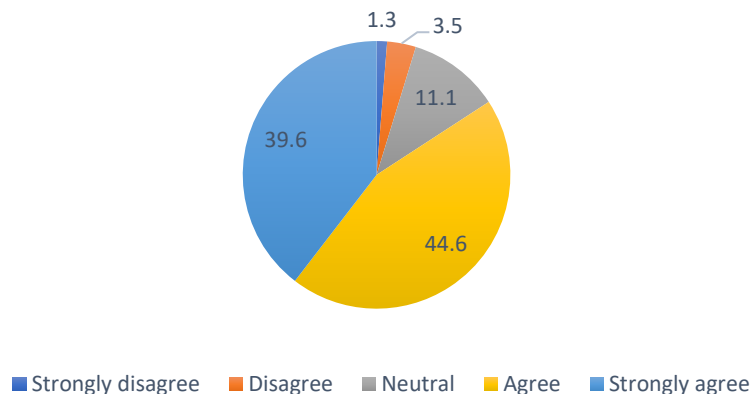
Figure 25: Results for Question 18

4.2.4.18 *Question 19*

Participants were asked to rate their response to the statement "If my public transport service is running very late, I would like to know which other service near me can take me where I want to go." This question was designed to test the applicability of **initial HCD Principle 3**, as well as **initial PT Principle 4, 5 and 6.** The results of this question are presented in Figure 26. Most of the sample strongly agreed (45.3%) and agreed (42.7%) to this statement, while the remainder responded neutrally (9.8%), strongly disagreed (1.3%) and disagreed (0.9%).
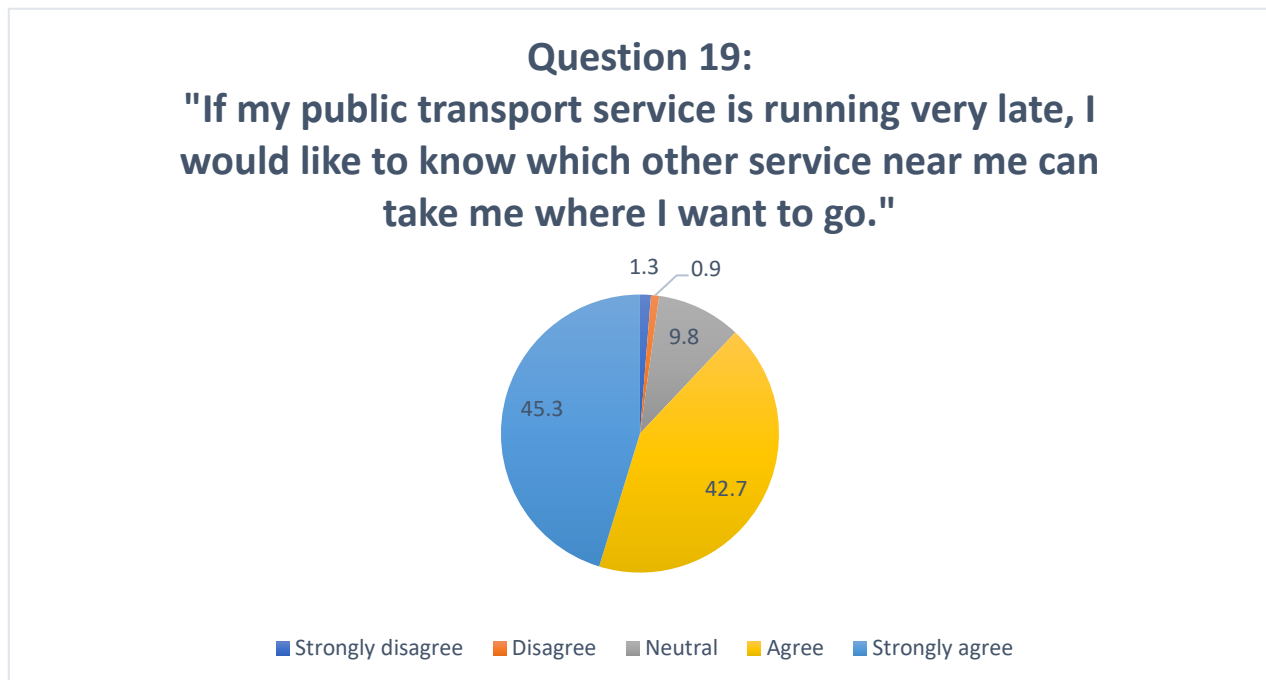
Figure 26: Results for Question 19

4.2.4.19 *Question 20*

Participants were asked to rate their response to the statement "When I am using a public transport service and it breaks down, I would like to know where to report the problem." This question was designed to test **initial HCD Principle 3** as well as **initial PT principle 4, 5 and 6.** The results of this question are presented in Figure 27. Just over half the sample (50.3%) strongly agreed to the statement, while another 38% agreed. The remainder of the sample responded neutrally (9.2%) and disagreed (2.5%); nobody strongly disagreed. One participant noted that it's not their problem if the taxi breaks down (thus disagreeing to the statement), while another asked that any reports are kept anonymous (agreeing to the statement)

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Question 20:
"When I am using a public transport service and it breaks down, I would like to know where to report the problem."

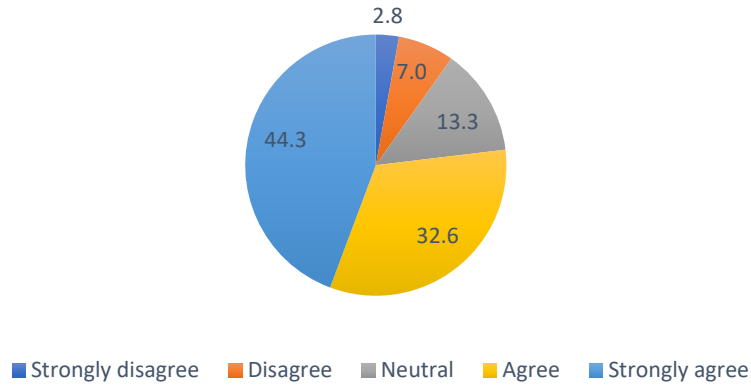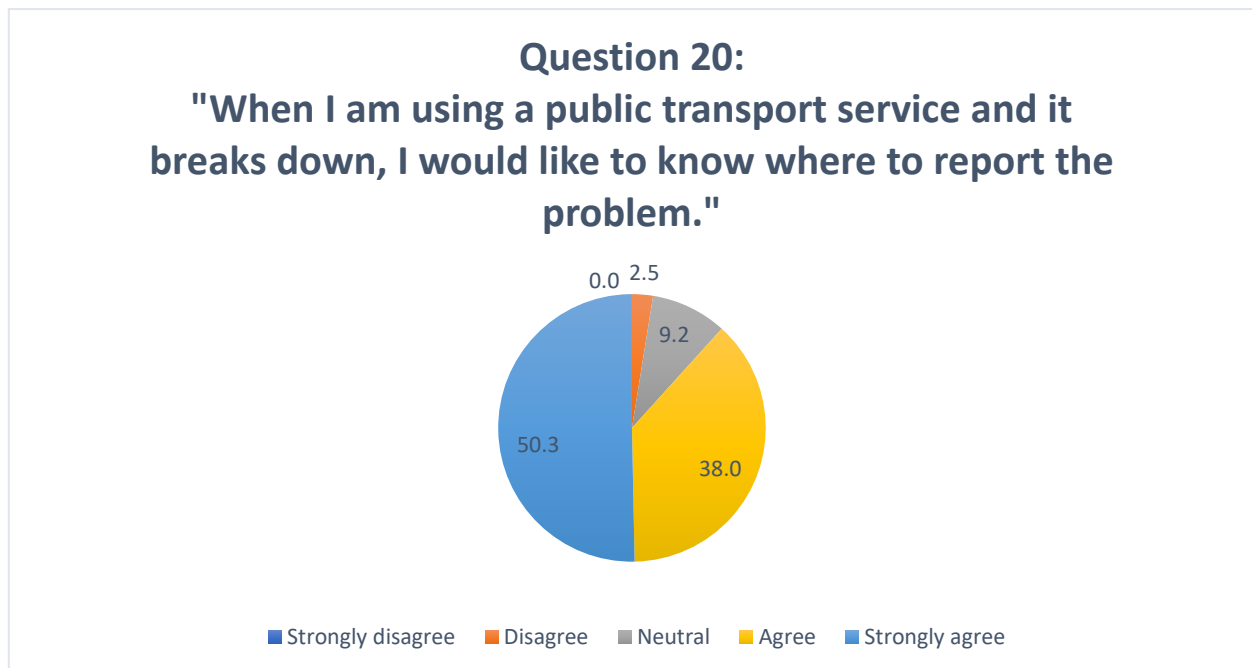*Figure 27: Results for Question 20*

4.2.4.20 *Question 21*

Participants were asked to rate their response to the statement "I would prefer paying for all my public transport using only one card, instead of carrying cash", in order to test the applicability of **initial PT Principle 3** and **initial PT Principle 4**. The results of this question are presented in Figure 28. Most of the sample strongly agreed (38%) and agreed (32.3%) to the statement posed, while the remainder of the sample responded neutrally (16.8%), disagreed (9.2%) and strongly disagreed (3.8%).

Question 21:
"I would prefer paying for all my public transport using only one card, instead of carrying cash."
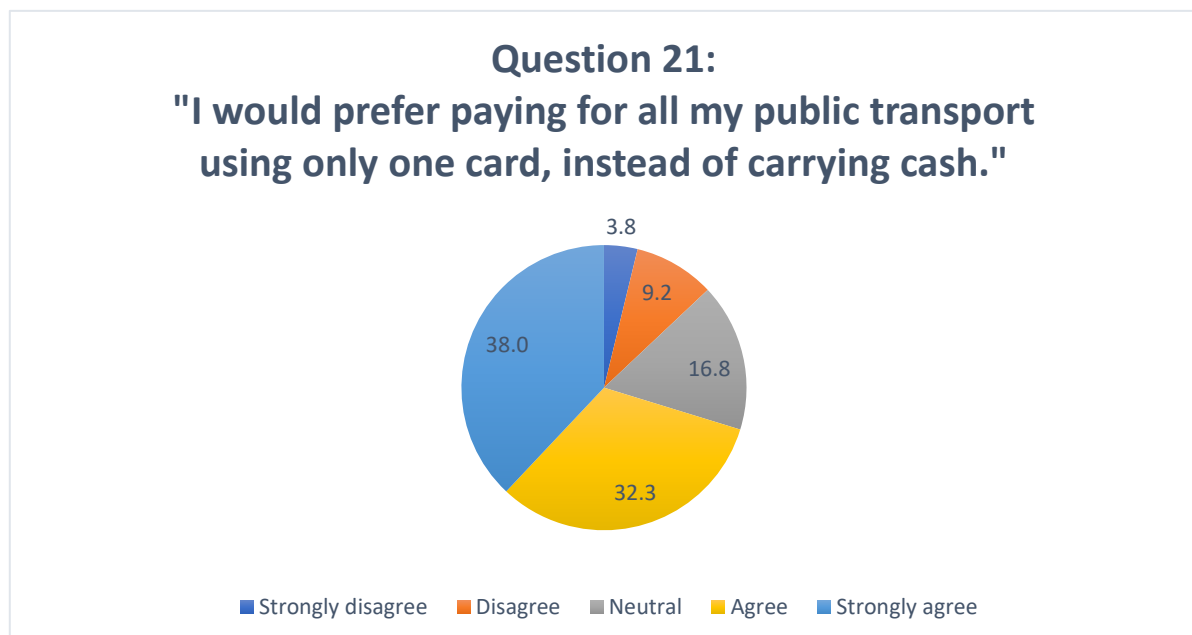
Figure 28: Results for Question 21

4.2.4.21 *Question 22*

The last three questions of the survey attempted to quantify how commuters would feel about certain scenarios in order to test the relationship between commuter's perception of a PT service and the degree to which the desire and value that service. Participants were asked to rate how they would feel if transport officials make a regular effort to understand their travel needs. This question tests the applicability of **initial HCD Principle 3, 4 and 6**, as well as **initial PT Principle 8**, the results of which are presented in Figure 29. Over half the sample (51.9%) said they would feel very happy if this occurred, while 103 participants (32.6%) said they would feel pleased. The remainder of the sample responded neutrally (10.8%) and, interestingly, said they would feel disappointed (2.5%) and angry (2.2%) if this was the case.
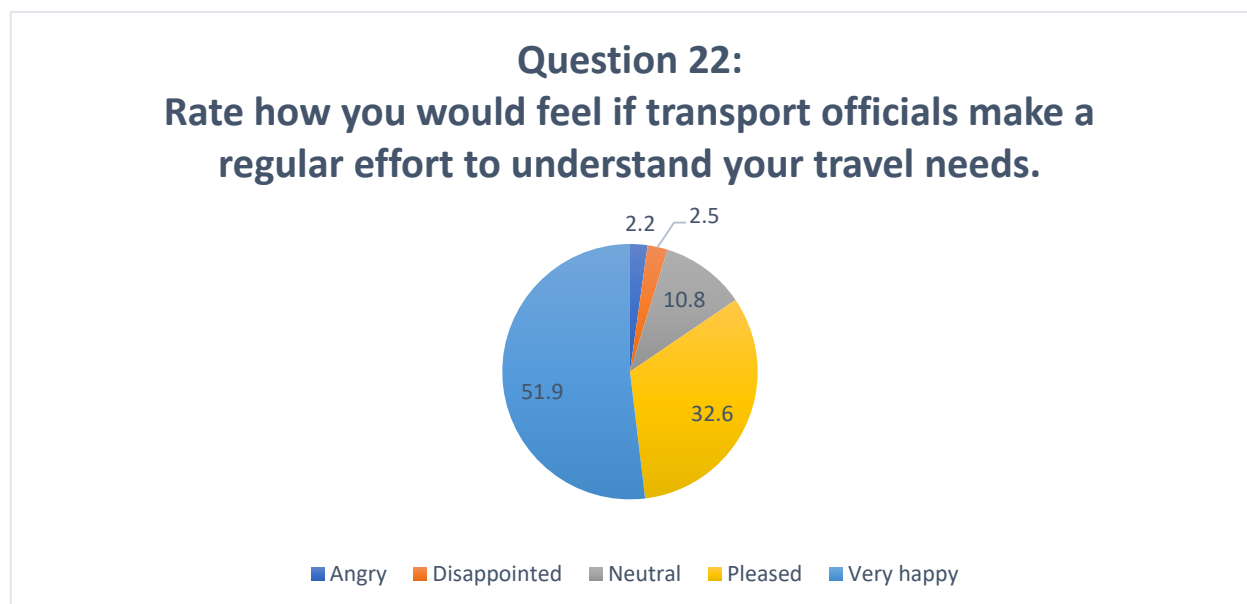
Figure 29: Results for Question 22

4.2.4.22 *Question 23*

Participants were asked to rate how they would feel if transport officials involve them when creating a PT service, in order to test the applicability of **initial HCD Principle 6 and 7** as well as **initial PT Principle 8**. The results of this question are shown in Figure 30. Again, over half the sample (50.6%) said they would feel very happy if this was the case, while 97 participants (30.7%) said they would feel pleased. The remainder of the sample responded neutrally (15.2%) or said they would feel disappointed (1.9%) and angry (1.6%) if this occurred.

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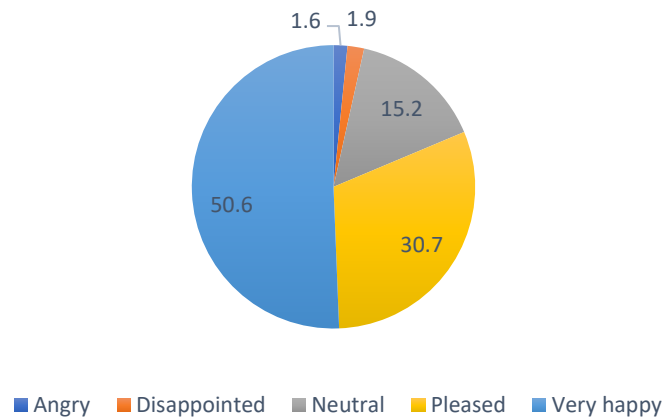
Figure 30: Results for Question 23

4.2.4.23 *Question 24*

Participants were asked to rate how they would feel if they have access to every PT service they want to use, in order to test the applicability of **initial PT Principle 2 and 7**. The results of this question are presented in Figure 31. A total of 210 participants (66.5%) said they would feel very happy if this was the case and 73 participants (23.1%) said they would feel pleased. The remainder of the sample responded neutrally (9.2%) and said they would feel disappointed (0.3%) and angry (0.9%).
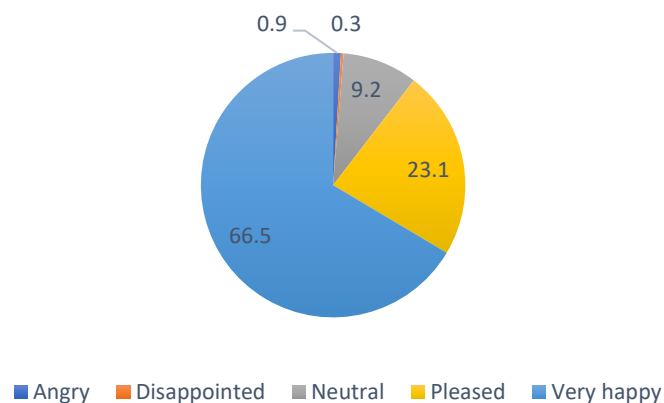
Figure 31: Results for Question 24

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4.2.4.24 Correlation analysis

4.2.4.24.1 Introduction

A correlation analysis was done to determine the correlation between the presence of HCD measures in Gauteng PT (**Variable A**) and the commuters' satisfaction with and desirability for these PT services (**Variable B**). Correlation is illustrated using a scatterplot diagram, which plots data points resulting from two variables on a two-dimensional *x-y* axis (Price et al., 2017). MS Excel™ then draws a line of best fit through these data points, after which the software produces a Pearson Correlation Coefficient, r, describing quantitatively how strongly two variables are related (Cooper & Schindler, 2001; Almeida, Queirós & Faria, 2017) – this is required to quantify the correlation between Variable A and Variable B.

Therefore, the first step towards quantifying this correlation was creating data points from the survey data. It should be made clear that correlation studies do not use the terms "independent variable" or "dependent variable" - a researcher merely witnesses how the variables behave in their natural habitat and attempts to quantify the relationship between them to inform the acceptance or rejection of the study's hypothesis (Price et al., 2017; Fleetwood, 2020; Almeida, Queirós & Faria, 2017). Remember, "correlation doesn't indicate causation" (Price et al., 2017; Almeida, Queirós & Faria, 2017), because of the:

1. **directionality** problem: either variable could affect the other - there lacks clarity "which is the cause and which is the effect" (Price et al., 2017; American Psychological Association, 2020)

2. **third-variable** problem: A and B could be statistically related not necessarily because A influences B or B influences A, but because a third variable, C, influences both A and B (Price et al., 2017; Almeida, Queirós & Faria, 2017)

4.2.4.24.2 Creating datapoints for correlation analysis

Nonetheless, in order to develop a scatterplot diagram for correlation to be estimated, a decision was made to make Variable A the x-value and Variable B the y-value – **this does not mean Variable A causes Variable B**, as this relationship could be inverted, or a third variable, C, could influence both these variables. This consideration is further discussed in the *Discussion* section of this study.

In order to create data points for correlation to be estimated, the researcher first sorted applicable survey questions into Variable A or Variable B, as shown in Table 16. The questions shown here resonated with either of these variables, thus representing a presence of HCD in Gauteng's PT services *or* a commuter's satisfaction with these PT services. Notably, not all questions were related to these variables, while some questions automatically tested this correlation – these questions were named *auto-correlation questions*.

Many different, logical combinations of Variable A survey questions (namely, *x*) and Variable B survey questions (namely, *y*) were then made to create a range of possible datapoints for the correlation analysis.

Figure 32 presents how this was done on MS Excel™. For example, the first combination that was made was between Question 12 and Question 22. Question 12 (*I would like the opportunity to give my ideas and create the transport service I use*) indicates the presence of HCD in Gauteng's PT (**Variable A**) and Question 22 (*Rate how you would feel if transport officials make a regular effort to understand your travel needs*) indicates how a commuter feels with their PT service and thus the degree to which their service satisfied them (**Variable B**).

Thus, survey question combinations were made from logical deduction **SUPPORTED BY LITERATURE** of whether the first question would influence the second question. Additionally, in order to generate these points, an assumption was made that the way a commuter *feels* is directly proportional to their *satisfaction* with that service. Thus, it was assumed that if a commuter has a *negative* emotion towards a service, they are *less satisfied* with that service.

Table 16: Questions sorted into different variable types for correlation analysis

Variable type	Survey questions assigned
A (presence of HCD in GP PT)	Questions 12, 14, 15, 18 and 20
B (commuter satisfaction and operational success)	Questions 4, 5, 6, 22, 23 and 24
Auto-correlation	Questions 10 and 13

4.2.4.24.3 Weighting system to quantify datapoint values

A simple weighting system was created to quantify the overall weighting for each question in the correlation analysis. This system is shown in Table 17.

Table 17: Weighting system used to quantify x and y values for datapoints

Response	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Weighting	-2	-1	0	+1	+2

As shown in Figure 32, an overall weighting score was determined for each survey question based on the above weighting system, quantifying either the x-variable or y-variable in a datapoint. Considering these overall weighting scores, most question combinations produced values that were relatively complementary. However, as shown by the yellow highlighting in Figure 32, three combinations did not, strongly indicating that no correlation existed between those questions.

Variable A						x-axis	positively	Variable B						y-axis	
Presence of HCD measures in GP PT							influences...	Commuter satisfaction with/desirability for PT							
							OVERALL WEIGHTING SCORE	Operational success of PT services							OVERALL WEIGHTING SCORE
I would like the opportunity to give my ideas and create the transport service I use.							Variable A	Rate how you would feel if transport officials make a regular effort to understand your travel needs.							Variable B
Q12	-8	-10	0	178	148		308	Q22	-14	-8	0	103	328		409
I would like the opportunity to give my ideas and create the transport service I use.								Rate how you would feel if transport officials involve you when creating a public transport service.							
Q12	-8	-10	0	178	148		308	Q23	-10	-6	0	97	320		401
Transport officials make an effort to understand what my biggest problems are and how they can help me.								Rate how you feel about this public transport service							
Q14	-98	-52	0	98	102		50	Q4	-66	-80	0	49	52		-45
Transport officials make an effort to understand what my biggest problems are and how they can help me.								I enjoy using this public transport service							
Q14	-98	-52	0	98	102		50	Q5	-92	-65	0	73	44		-40
Transport officials make an effort to understand what my biggest problems are and how they can help me.								If this public transport service becomes more expensive, I will pay more to use it							
Q14	-98	-52	0	98	102		50	Q6	-150	-77	0	77	42		-108
Transport officials will understand my needs better if they regularly use the same service I use.								Rate how you would feel if transport officials make a regular effort to understand your travel needs.							
Q15	-20	-24	0	134	194		284	Q22	-14	-8	0	103	328		409
Transport officials will understand my needs better if they regularly use the same service I use.								Rate how you would feel if transport officials involve you when creating a public transport service.							
Q15	-20	-24	0	134	194		284	Q23	-10	-6	0	97	320		401
I would like to know if my public transport service will be late.								Rate how you would feel if transport officials make a regular effort to understand your travel needs.							
Q18	-8	-11	0	141	250		372	Q22	-14	-8	0	103	328		409
I would like to know if my public transport service will be late.								Rate how you would feel if transport officials involve you when creating a public transport service.							
Q18	-8	-11	0	141	250		372	Q23	-10	-6	0	97	320		401
I would like to know if my public transport service will be late.								Rate how you would feel if you have access to every public transport service you want to use.							
Q18	-8	-11	0	141	250		372	Q24	-6	-1	0	73	420		486
When I am using a public transport service and it breaks down, I would like to know where to report the problem.								Rate how you would feel if transport officials make a regular effort to understand your travel needs.							
Q20	0	-8	0	120	318		430	Q22	-14	-8	0	103	328		409
When I am using a public transport service and it breaks down, I would like to know where to report the problem.								Rate how you would feel if transport officials involve you when creating a public transport service.							
Q20	0	-8	0	120	318		430	Q23	-10	-6	0	97	320		401
When I am using a public transport service and it breaks down, I would like to know where to report the problem.								Rate how you would feel if you have access to every public transport service you want to use.							
Q20	0	-8	0	120	318		430	Q24	-6	-1	0	73	420		486

Figure 32: How datapoints for the correlation analysis were created from quantitative survey data

4.2.4.24.4 First iteration of correlation analysis

Based off the correlation analysis shown in Figure 33 and including the three outlier data points, the scatterplot in Figure 35 was generated, boasting the following Pearson Correlation Coefficient:

$$r = \sqrt{r^2} = \sqrt{0.965} = 0.982$$

As such, a *positive* relationship exists between Variable A and Variable B, where the increased provision of HCD measures in Gauteng PT services causes an increase in commuter satisfaction with these services (Price et al., 2017). Therefore, even when including these three outlier datapoints, a 98.2% correlation between Variable A and Variable B exists. It is interesting to note that even when three outliers were included, the correlation percentage remained high, indicating that the remaining datapoints had a strong correlation. For this reason, it was considered satisfactory to leave these outliers in the dataset.

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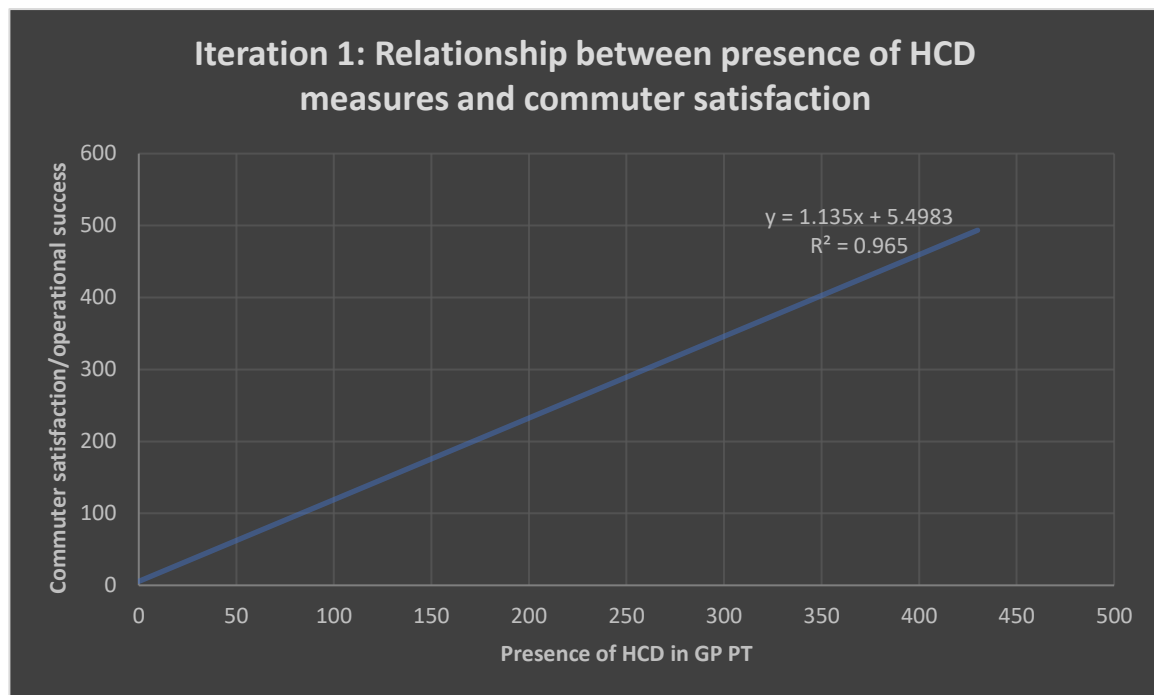
Figure 33: First iteration of the scatterplot correlation analysis

4.2.4.24.5 Auto-correlation questions

Two survey questions automatically quantified the correlation between Variable A and Variable B, namely:

1. Question 10: *If you see the items you selected in a waiting room, would you pay more to use this public transport service?*

2. Question 13: *I would be more interested in using public transport if my inputs were used to improve the service I use.*

In both cases, the response to the question directly indicates what commuters' satisfaction with a PT service would be if HCD (making human needs the centre of design) is incorporated into their service provision. The following overall weighting scores for these questions were calculated using the weighting system shown in Table 17, as follows:

- Question 10 = (-2 x 14) + (-1 x 45) + (0 x 77) + (1 x 109) + (2 x 67) = 170 **> 0**
- Question 13 = (-2 x 3) + (-1 x 8) + (0 x 43) + (1 x 154) + (2 x 108) = 356 **> 0**

Further discussion on the meaning of these values are offered in the discussion section of this study.

4.2.4.25 *Quantification of initial principle applicability*

In order to make a reasonable, informed decision about which initial principles should be selected to construct the final HCPTD Principles, the applicability of each principle was quantified based off the quantitative survey data results. Table 18 illustrates a summary of the questions that tested each of the 15 initial principles. A column is then provided to determine what the maximum weighting score would be if the principle was perfectly applicable. Then, a comparison is made between the latter and the overall weighting score obtained, and a *weighting comparison percentage score* (WCPS) is given to estimate how applicable this principle was based on the data obtained.

For principles which are tested by more than one question, an average percentage score is determined. Note that a percentage score of 100% would show perfect applicability of this principle from the views of the 316-person sample, while 0% would indicate a non-existent applicability of that principle from the sample's perspective. Note that only questions *with* a weighting score were included in Table 18, while the applicability of the remainder of the questions are considered in the discussion section. These questions include:

- Question 1 -2 for **initial PT Principle 2 and 7**
- Question 4 – 6 for **initial HCD Principle 5**
- Question 7 for **initial PT Principle 1 - 3**
- Question 8 in **Discussion/Recommendations**
- Question 11 in **Discussion/Recommendations**
- Question 14 for **initial HCD Principle 4**

The data form Question 9 does not align with any initial principle but can come in handy in the recommendations section. Question 14, in particular, had an overall weighting score of 50, but would have a maximum weighting score of -2 (strongly disagree) x 316 = -632 if initial HCD Principle 4 was perfectly applicable. A percentage score of **-7.91%** would have emerged, which would hugely affect the reliability of initial HCD Principle 4's overall weighting score. Thus, its weighting was omitted from this analysis, and its applicability considered in the discussion section.

Table 18: Summary of initial principle questions and overall weighting scores

Principle tested	Questions that tested it	Maximum weighting score for perfect applicability	Overall weighting score obtained (WCPS)
Initial HCD Principle 1: *Never assume*	Question 14	-	284 (**44.9%**)
Initial HCD Principle 2: *Consider the entire ecosystem*	Question 17	2 (strongly agree) x 316 = 632	343 (**54.3%**)
Initial HCD Principle 3: *Centralise people's needs, desires and feedback in the design process*	Question 13	2 (strongly agree) x 316 = 632	356 (**56.33%**)
	Question 16	2 (strongly agree) x 316 = 632	244 (**38.61%**)
	Question 18	2 (strongly agree) x 316 = 632	372 (**58.86%**)
	Question 19	2 (strongly agree) x 316 = 632	410 (**64.87%**)
	Question 20	2 (strongly agree) x 316 = 632	430 (**68.03%**)
	Question 22	2 (strongly agree) x 316 = 632	409 (**64.72%**)
			→ 58.6%
Initial HCD Principle 4: *Practical empathy*	Question 13	2 (strongly agree) x 316 = 632	356 (**56.33%**)
	Question 14	-	-
	Question 15	2 (strongly agree) x 316 = 632	284 (**44.94%**)
	Question 22	2 (strongly agree) x 316 = 632	409 (**64.72%**)
			→ 55.3%
Initial HCD Principle 5: *Enhance a commuter's perceived value when designing*	Question 4	*No weighting analysis done here. Results discussed in* Discussion *section.*	-45
	Question 5		-40
	Question 6		-108
Initial HCD Principle 6: *Collaboration and consultation with stakeholders*	Question 12	2 (strongly agree) x 316 = 632	308 (**48.73%**)
	Question 13	2 (strongly agree) x 316 = 632	356 (**56.33%**)
	Question 22	2 (strongly agree) x 316 = 632	409 (**64.72%**)
	Question 23	2 (strongly agree) x 316 = 632	401 (**63.45%**)
			→ 58.3%
Initial HCD Principle 7: *People-centred development*	Question 9	-	-
	Question 10	2 (strongly agree) x 316 = 632	170 (**26.9%**)
	Question 11	-	-
	Question 12	2 (strongly agree) x 316 = 632	308 (**48.73%**)
	Question 23	2 (strongly agree) x 316 = 632	401 (**63.45%**)

			→ **46.4%**
Initial PT Principle 1: *Prioritise safe, reliable and affordable transport services*	Question 7 Question 8	*No weighting analysis was done here. Applicability considered in discussion.*	- -
Initial PT Principle 2: *Provide access to as many commuters as possible to use PT services*	Question 1 Question 2 Question 7 Question 8 Question 24	- - - - 2 (strongly agree) x 316 = 632	- - - - 486 (**76.9%**)
Initial PT Principle 3: *Convenience: connectivity, ease of transfers and ease of interoperability*	Question 7 Question 8 Question 21	- - 2 (strongly agree) x 316 = 632	- - 289 (**45.7%**)
Initial PT Principle 4: *Prioritise network integration*	Question 16 Question 18 Question 19 Question 20 Question 21	2 (strongly agree) x 316 = 632 2 (strongly agree) x 316 = 632 2 (strongly agree) x 316 = 632 2 (strongly agree) x 316 = 632 2 (strongly agree) x 316 = 632	244 (**38.61%**) 372 (**58.86%**) 410 (**64.87%**) 430 (**68.03%**) 289 (**45.73%**) → **55.2%**
Initial PT Principle 5: *Aligning institutional priorities with PT development*	Question 14 Question 16	- 2 (strongly agree) x 316 = 632	- 244 (**38.61%**)
Initial PT Principle 6: *Developing local management structures for PT operations*	Question 18 Question 19 Question 20	2 (strongly agree) x 316 = 632 2 (strongly agree) x 316 = 632 2 (strongly agree) x 316 = 632	372 (**58.86%**) 410 (**64.87%**) 430 (**68.03%**) → **63.9%**
Initial PT Principle 7: *Define the roles and function of every mode*	Question 1 Question 2	*No weighting analysis was done here. Applicability considered in discussion.*	- -
Initial PT Principle 8: *Promote collaboration and interaction between various stakeholders*	Question 12 Question 13 Question 22 Question 23	2 (strongly agree) x 316 = 632 2 (strongly agree) x 316 = 632 2 (strongly agree) x 316 = 632 2 (strongly agree) x 316 = 632	308 (**48.73%**) 356 (**56.33%**) 409 (**64.72%**) 401 (**63.45%**) → **58.3%**

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4.3 Discussion of findings

Phase 2 of this study was designed to test and/or reinforce the findings of Phase 1. Thus, this section discusses what the quantitative survey data implies about the initial HCD- and PT Principles it was designed to test. Considering the analysis of the survey data that was presented in section 4.2.4, an informed decision is now made on which initial principles should be considered when creating the final HCPTD Principles, which are generally combined principles of HCD and PT design that are most relevant to Gauteng PT services and of the greatest priority to the development and success of these service.

4.3.1 Applicability of initial principles

Based on the weighting comparison analysis done in Table 18 and the results of the questions who could not be weighted (but still tested particular initial principles), a discussion on the applicability of each initial principle is now offered. In order to marry related HCD- and PT principles together to create the final HCPTD principles, the same number of initial principles must be selected from either study construct.

4.3.1.1 *Discussion of initial HCD principles*

4.3.1.1.1 Initial HCD Principle 1 - Never assume

Question 14 tested the applicability of this initial principle. While the spectrum of responses were fairly evenly distributed, the largest portion of the sample agreed (31%) that transport officials make an effort to understand what their biggest problems are and how they can help them and 20.9% responded neutrally, thus having no specific views to add on the matter.

An overall weighting score of 50 was observed for this question, meaning commuters overall supported the view that transport officials *do* make an effort to understand their biggest problems and how they can help them. Since the score is > 0, the sample basically implies that Gauteng transport officials *aren't* assuming and that they *are* actually making an effort to understand and provide for their travel needs. Therefore, further development of this initial principle is not justified, as the data from Question 14 does not support it.

4.3.1.1.2 Initial HCD Principle 2 – Consider the entire ecosystem

Question 17 tested the applicability of this initial principle. According to Table 18, a **$WCPS_{17}$ = 54.3%** was observed. As such, over half of Gauteng's adult commuters support this initial principle. The bulk of the sample strongly agreed (44.3%) and agreed (32.6%) that poor PT services negatively affects their lifestyles and their jobs, meaning over three-quarters of the sample (76.9%) agreed. Since this was the only question that tested this principle, it is clear that commuters notice the impact poor PT services have on their lifestyles and their jobs, subtly implying that the *entire* ecosystem around PT must be considered during design and supporting HCDE3's view (HCDE3:I19). Furthermore, this illustrates a good understanding that

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"activities do not exist in isolation: they are components of complex sociotechnical systems" (jnd.org, 2019). Therefore, further development of this principle is justified, as the survey data strongly supports it.

4.3.1.1.3 Initial HCD Principle 3 - Centralise people's needs, desires and feedback in the design process

Questions 13, 16, 18, 19, 20 and 22 tested the applicability of this initial principle, producing an average **WCPS$_{avg}$ = 58.6%**. Given how large even the *average* WCPS is, far over half of Gauteng's adult commuters support the applicability of this initial principle. This implies that most Gauteng PT users support their needs, desires and feedback being centralised and prioritised in the PT design process. Furthermore, this score shows that commuters also support HCDE1's view that the poor quality and reliability of South Africa's infrastructure is a result of a lack of human-centric service delivery (HCDE1:I6) as well as the concept of human-centred mobility (Mitchell, Claris & Edge, 2016) and the smart city concept (Ballas, 2013).

One participant noted that it's not their problem if the MBT service breaks down, strongly favouring HCD as this involves understanding the perspective and central needs of those who are faced with a problem and ultimately designing services, products or systems tailor-fitted to meet those needs (Design Kit, 2021; DC Design, 2017). Another participant requests that any reports are kept anonymous. As such, the further development of this initial principle is justified because the survey data strongly supports it.

4.3.1.1.4 Initial HCD Principle 4 - Practical empathy

Questions 13 – 15 and Question 22 tested the applicability of this initial principle, producing an average **WCPS$_{avg}$ = 55.3%**. Such a large average WCPS score indicates that far over half of Gauteng's adult commuters support this principle. Thus, most of Gauteng PT users support HCDE3's view of PT designers becoming regular commuters to understand the travel needs of their customers (HCDE3:I25) and that if they are treated better and heard, the efficiency of PT service provision would improve (HCDE3:I23). This view is reinforced by one participant that says Gauteng transport officials are "not doing anything to solve my problems", while another participant stated that "they still won't care" even if transport officials use the same service they used. These strong comments indicate that commuters do not feel as if transport officials empathise with their transport issues and thus do not care about what they go through on a daily basis.

Thus, these commuters support practical empathy being incorporated into Gauteng's PT service provision, implying that practical empathy would develop excellent transport designs that are desirable to them (Mad Pow, 2021), improving the need and thus demand for that service (PTE2:I10). Further developing this initial principle is thus justified because the survey data support it.

4.3.1.1.5 Initial HCD Principle 5 - Enhance a commuter's perceived value when designing

HCDE1 stated that value is equal to desire (HCDE1:120) and in order to understand how much a person *values* something, understanding a person's *perception* thereof is essential (HCDE1:I5). Commuter perceptions were tested using emotive responses to certain survey questions, assuming that perception is equal to how people feel.

Questions 4 – 6 tested the applicability of this initial principle. An overall weighting score of -**45** was observed for Question 4 when commuters were asked how they feel about their PT service. Since this is < 0, the sample generally had a negative feeling towards their PT service, meaning their perception thereof is also negative. Interestingly, an overall weighting score of -**40** was observed for Question 5, indicating that Gauteng Pt users generally **do not** enjoy their PT service. Here, *enjoyment* was related to *desire*. For Question 6, an overall weighting score of **-108** emerged, suggesting that commuters generally **would definitely not** pay more for their PT service if it became more expensive – this is clear because the weighting value for Question 6 was over two times larger than Questions 4 or 5. The amount they are willing to *pay* links to the *value* they place on the service.

It should be noted that **eighteen** participants declared they had no other option than to pay more if their PT service became more expensive, stating that they have no other transport alternatives and need to live with fare increases. While the data for these responses are > 0 for Question 6 (namely, agree), these comments strongly suggest that these users are held captive to the service they are using and thus had no other option but to pay more if a PT service became more expensive. Arguably, this suggests a relatively poor perception and desire for these services, since commuters are left without a choice of travel alternative.

The survey data thus illustrates a strong correlation between perception and desire, showing that those who had a **negative** perception of their service (-45) desired (or enjoyed) it **less** (-40), *and* were definitely **not willing** to pay more for it if it became more expensive (-108), describing the value they place on the service. Given all three weighting scores for these questions were well below 0, the following conclusion can be made:

$$Perception\ (emotion) \propto Desire\ (enjoyment) \propto Value\ (willingness\ to\ pay)$$

As such, making an "investment in infrastructure that recognises human desires" (HCDE3:I24) may in fact offer transport businesses the increased patronage and growth they desire (HCDE1:I20). Thus, Gauteng PT users agree that they would look after their PT services better and be willing to pay more for them if the service is perceived as more valuable (HCDE1:I28). Thus, if services operate and comply with passenger needs, then they "will be successful moving forward", as commuters will then perceive the service as more valuable and be prepared to pay more to use that service (PTE3:I27). Given the strong correlation found

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between the survey data from Questions 4 – 6, further development of this initial principle is definitely justified.

4.3.1.1.6 Initial HCD Principle 6 - Collaboration and consultation with stakeholders

Questions 12, 13, 22 and 23 tested the applicability of this initial principle, producing an average **WCPS$_{avg}$ = 58.3%.** Such a large average WCPS score indicates that far over half of Gauteng's adult commuters support this principle. As such, most of Gauteng's PT users support HCDE2's view that incorporating authentic, collaborative stakeholder consultation into South Africa's PT design model is one means of enhancing customer satisfaction in South African transportation (HCDE2:I42). This strong weighting score also indicates that Gauteng commuters *want* to be involved in the PT design from its onset (PTE3:I37; Herriott, 2011) and would like to be consulted throughout a PT design process (HCDE2:I12). Furthermore, the provision of negotiating forums (where authorities and commuters can have a regular engagement) (HCDE2:I10) is supported by Gauteng PT users, in addition to building stakeholder's consultation into the PT design model (HCDE2:I42). Due to the strong WCPS score produced by the survey data, further development of this principle is definitely justified.

It should, however, be noted that authorities do conduct stakeholder consultation in different stages of PT design and development, as transport forums for stakeholders to express their views and consistent stakeholder consultation in all transport-related endeavours are becoming a societal norm (Department of Transport (RSA), 2020c). The GMA's 2019/2020 integrated annual report makes reference to "[f]ostering strong and committed relationships through strategic partnerships, regular engagement, building an inclusive and cohesive employee culture" (p15), "[e]ngagement with internal stakeholders" that "included electronic communication and events such as staff meetings" (p71), "engagement with key public transport stakeholders to discuss integration initiatives and to co-ordinate transport planning" (p96) and "critical stakeholder consultation and engagement" (p98) (Gautrain Management Agency, 2020). The latter illustrates that Gauteng's PT authorities implement regular engagement with their stakeholders, but Gauteng PT users would not indicate this on their survey unless they were involved in aspects of such engagement or aware that this engagement was occurring.

Moreover, PT authorities such as the Gautrain also engage informally with commuters through social media, enabling incident management to be triggered before formal structures report a challenge experienced by commuters. The above-mentioned integrated annual report indicated that the GMA had "developed a strong Digital Marketing Strategy" focussing on "increasing Gautrain's Social Media presence, following and engagement" (p69). This included paid advertising on Facebook™, Instagram™ and Twitter™ to reach new target audiences, showcasing new midibus routes and fares on social media (leading to a 23% increase in midibus ridership) and developing a lifestyle microsite where people can view current Gautrain

campaigns and access related information. The GMA reported that over 3000 people had visited the GMA website in one year, boasting near to 54,000 Facebook™ fans, just over 290,000 followers on Twitter™ and just over 2000 followers on Instagram™, where 77% of social media posts were neutral and 12% were positive (p71) (Gautrain Management Agency, 2020).

After the 2010 Soccer World Cup, the GMA strategically utilised its social media presence to promote "increased public participation in the planning process" (p7) and monitor and evaluate its service quality. Information was obtained from commuters relating to delays, queries and complaints on the transport service, thus building authentic, collaborative relationships with social media users and promoting transparency and accountability. The GMA uses social media information as a tool to enhance the perception customers have of their brand (even before the construction phase), using positive feedback from commuters to attract more customers through marketing and reduced fares. Social media information is thus filtered accordingly and shared with commuters so that operational information is available in real time and, if necessary, allows commuters to make other travel arrangements. As such, this information can be processed to enhance Gautrain's service delivery and promote it as a smart PT system that commuters want to be associated with (Musakwa, 2014).

4.3.1.1.7 Initial HCD Principle 7 – People-centred development

4.3.1.1.7.1 Implications of WCPS

Questions 9 – 12 and Question 23 tested the applicability of this initial principle. It is interesting to note that even when given eight different options to choose from, only just over half the sample (56.4%) agreed that they would pay more to use that PT service if they saw the items they selected in the PT waiting room; 18.9% disagreed. As a result, a low $WCPS_{10} = 26.9\%$ was observed for Question 10, lowering the average score to $WCPS_{avg} = 46.4\%$ even when Question 12 ($WCPS_{12} = 48.7\%$) and Question 23 ($WCPS_{23} = 63.5\%$) had relatively high scores. As an explanation, one participant disagreed because they don't have more to spend, while another said they aren't happy with the service they receive. Thus, even when given all the items they desire when waiting for PT, some Gauteng commuters won't pay more due to a lack of funds or because they aren't receiving a pleasant service; another participant agreed only if they receive a "full service".

The low weighting value of $WCPS_{10} = 26.9\%$ indicates that nearly three-quarters (73.1%) of Gauteng's commuters would *not* pay more to use a PT service, even if they have access to free Wi-Fi (24.9%), comfortable seating (20%) or a travel information board (13.7%), or see security cameras (21%), disabled facilities (8.3%) or local artwork (5.3%). Since $WCPS_{avg} < 50\%$, more than half of Gauteng commuters are not in favour of people-centred development, arguably because they still aren't pleased with the PT service they are receiving (as one participant mentioned) and will thus only pay more if they receive a better

transport service. Two participants mentioned they would only pay more for PT if they have more money to spend, meaning some Gauteng PT users don't have more to spend on PT than they currently have.

Because WCPS$_{avg}$ < 50%, it does not seem plausible to develop this initial principle further. Nonetheless, **WCPS$_{avg}$ = 46.4%** illustrates that this initial principle still holds promise, as Question 12's results show that an estimate of 48.7% of Gauteng's PT users would like the opportunity to give their ideas and create the transport service they use, while 81.3% responded positively to transport officials involving them when creating a PT service (Question 23). This principle should thus still be considered in the study's discussion and recommendation sections later on.

4.3.1.1.7.2 Results for Question 11

Participants were asked if there was anything else they would like to see in the PT waiting area besides the options shown. The top five results are reported on based on Table 15. A total of 43 commuters (30.5%) made comments relating to *safety and security*, requesting that security guards keep the area safe at all times (24.8%), with three participants asking for security cameras to be installed and to be kept safe, respectively. The large portion of these comments indicates that it is important for Gauteng PT users to feel safe when waiting for and accessing PT.

Interestingly, 27 participants (19.1%) made comments related to *food, drinks and purchases*, requesting free food and snacks (5.7%), water fountains (four responses) and coffee or coffee shops nearby (four responses). Other requests include a refreshments area (four responses) and having shops nearby PT hubs (three responses). Next, 21 participants (14.9%) made comments related to *entertainment*, including an entertainment area (4.3%), televisions (3.5%) and charging stations (two responses), while 17 participants commented on *bathrooms and hygiene*, asking for clean restrooms with running water (8.5%) and cleanliness both on and off PT vehicles (three responses). Lastly, 15 comments were made regarding *comfort and seating*, requesting more comfortable seating (7.8%) and more sheltered areas (three responses).

If 176 participants (55.7%) agreed to pay more to use a PT service if they saw the items they selected in the waiting area, its highly likely they would do the same for any recommendations they made in Question 11. Thus, these results should be utilised during the rest of the discussion to add context and depth to the findings, as they may highlight crucial themes that could reinforce the findings of initial principles that are developed further.

4.3.1.2 *Discussion of initial PT principles*

4.3.1.2.1 Initial PT Principle 1: Prioritise safe, reliable and affordable transport services

Question 7 and 8 tested the applicability of this initial principle. Because no weighting value could be assigned to this principle in Table 18, its applicability is investigated by considering the results of these survey questions, with support from Question 11. The results of Question 7 observed that, out of the eight issues stated, Gauteng commuters are concerned with the:

- Poor maintenance of their service (22.2%)
- Lack of safety of their service (18.5%)
- Unreliability of their service (14.6%)
- Affordability of their service (11.2%)

4.3.1.2.1.1 Discussion of the findings

4.3.1.2.1.1.1 *Findings supporting physical network integration*

In Question 18, 84.2% of the sample agreed that would like to be informed if their transport will be late. According to Ibrahim (2003), integration of a PT system serves the enhanced provision of travel information, journey planners and trip booking systems. Travel information provided in an integrated system offers real-time information on mode locations as well as arrival and departure times by means of information display panels (Ibrahim, 2003). Cohen et al. (2017) adds that an increased use of digital mobility applications like Google Maps™ and Uber™ creates the need to better optimise these services such that they more rapidly respond to the demands and travel habits of commuters.

If this is the case, an integrated PT application would have the potential to update waiting commuters on arrival times so commuters know how late their services will be. Thus, the purpose of Question 18 is to test a commuter's response to the *infrastructure development* step of **physical integration** (Ibrahim, 2003). Bus locations in Singapore's PT system are tracked using an Integrated Bus Operating System (IBOS), while PT trip journeys can be sequentially planned using electronic travel guides that consider the trip cost, minimum travel time and number of transfers required from origin to destination (Ibrahim, 2003). Therefore, an "electronic travel guide" can also inform commuters if a service will be running late, further supported by PTE3 who says effective communication between drivers and the proposed integrated PT control centre should be maintained so that control centres can communicate with waiting commuters to arrange alternative means of transportation, if necessary (PTE3:I25).

As such, commuters will have the option to select another transport service near them on the integrated PT application that can take them to their desired destination, in the event that their service is unsatisfactorily late. In Question 19, a total of 266 participants (88%) agreed that if their PT service is

running late, they would like to know which other service near them can take them where they want to go. Since Question 19 tested how commuters would respond to the *integrated information* portion of the second network integration step (**physical integration**) (Ibrahim, 2003; Fang & Zimmerman, 2015), this indicates that Gauteng commuters strongly approve of the idea of network integration and the integrated PT application that would result.

Linking well to the proposed integrated PT application, commuters can post reports on the application in the event that a service vehicle would break down, so that local transport authorities are informed and another vehicle can be sent immediately to get commuters to their destination. While no literature mentions this, PTE3 and the survey data supports this notion.

PTE3 explains that in the event of exceptions such as bus breakdowns or late arrivals, drivers should be able to communicate with the integrated PT control centre to inform them of the exception so that the rail service can be held back. Commuters should then be swiftly informed of any schedule changes (PTE3:I39). Furthermore, in Question 20 (also designed to test commuter responses to *integrated information*), a total of 279 participants (88.3%) said they would like to know where to report the problem if the PT service they are using breaks down. Again, this indicates that Gauteng commuters strongly approve of the idea of an integrated PT *application* and an integrated PT *system*, as the integrated PT control centre would have the potential to manage modes in the network *and* provide real-time updates of arrival times. While not at all mentioned in literature, PTE3 believes integration plans will not exist without the proposed planning offices, claiming the inability to address commuter requirements is believed to result from a lack of "integrated planning offices at local municipality level" (PTE3:I30).

4.3.1.2.1.1.2 Findings supporting operational network integration

Further support for Gauteng commuters' approval of network integration is provided by the findings of Question 21, which tested how commuters would respond to the *common ticketing systems* portion of **operational integration**. The use of a common ticket fare system establishes a common ground for operators of different PT modes to integrate their services and share revenue in an integrated PT network (Nielsen, Nelson & Mulley, 2015; Menckhoff, 2005). A total of 222 participants (70.3%) agreed that they would prefer paying for all their PT using only one [smart] card, instead of carrying cash. The enormous support for an integrated PT card from which all PT fares can be paid indicates that Gauteng PT users strongly support the idea of a common ticket fare system and thus network integration.

In Question 11, one participant requested that a SpeedPoint™ payment system like Pay2Pay™ is installed in the waiting area for PT because, "Working with change is admin", while in Question 7, one participant asked, "Why do we have to count money for the drivers?". These comments indicate that Gauteng PT users are frustrated with the current payment system employed in these services, often involving working with

change and being expected to give all customers change while also being a passenger. With 70.3% of the sample agreeing to pay for all their PT services using only one card, a desire for an electronic payment system in Gauteng's PT service is being demonstrated.

Singapore, for instance, presented their Enhanced Integrated Fare System in 2002 that allows fares to be paid by holding a Smart Card next to a card reader. The fare cost was then deducted from the card, thus enhancing the service's LOS by speeding up the transaction rate (Ibrahim, 2003). Contactless, electronic fare payment such as these are being introduced globally to tackle crime and ensure trip fares are paid after using a service. Here, trips are paid based on the distance or duration of the trips (as opposed to the number of transfers) and all revenue in the integrated system is split evenly among the number of PT service operators (Fang & Zimmerman, 2015).

4.3.1.2.1.1.3 Conclusion

Since $WCPS_{avg} > 50\%$ was observed for this initial principle, over half Gauteng commuters support the idea of **physical** integration (integrated PT application and control centre) and **operational** integration (common ticketing systems). Considering the strong support towards integrated information, infrastructure development (the integrated PT control centre) and common ticketing systems that was demonstrated by these findings, further development of this initial principle is definitely justified.

4.3.1.2.1.2 Safety and security

Arguably, poor maintenance of a PT service relates strongly to a commuter's sense of perceived safety. Several participants explained that some MBT services they use were so poorly maintained that they could see the road through the bottom of the vehicle, while another participant stated that some MBTs are unsafe because the vehicle's door was broken. In support of this, the greatest number of responses to Question 8 (17.4%) said that better roadworthiness and maintenance of vehicles would improve their travel journey, requesting well-maintained vehicles (11.3%), newer, upgraded taxis (5 responses) and roadworthy vehicles (2 responses).

Relating to the latter, a total of 160 participants (second highest response to Question 7) were unhappy because their PT service is unsafe. Given that 43 commuters (30.5%) made comments relating to *safety and security* in Question 11 (the highest proportion of responses for this question), Gauteng commuters have a strong desire to feel safe when waiting for and using PT. Nearly a quarter of responses in this question (24.8%) requested the continual presence of security services in the waiting area to maintain the safety of the area, while other participants asked for security cameras to be installed (3 responses), to be kept safe (3 responses) and that regular security check-ups, lighting and maximum security at night are provided. Furthermore, 20 comments (9.4%) were made regarding safety and security in Question 8, stating

that being kept safe during their travels (11 responses), security being deployed (4 responses) and safety for pedestrians and at the taxi ranks (2 responses) would make their travel journey better.

With the above considered, Gauteng PT users express an important desire to feel safe when waiting for and using PT services. This supports the view of Lombard and Hugo (2002) that two-thirds of Cape Town commuters did not make use of rail services due to the lack of safety offered by the service, among other things, and that poor transport service quality is characterised by issues like lack of safety and security (Shaw, 2006; Barrett, 2004). With relatively high question proportions of 40.7% (Question 7), 26.8% (Question 8) and 30.5% (Question 11) relating to this subject, safety and security should be a vital consideration when designing Gauteng's PT services. To compare its importance to other PT design considerations, an average of **32.7%** of the sample expressed views in this regard.

4.3.1.2.1.3 Reliability

In Question 7, the third highest portion of the sample (14.6%) expressed that the unreliability of their PT service made them unhappy, while 12.2% of Question 8's responses related to punctuality, reliability and swiftness of their service having the potential to better their travel experience. This related to services arriving on time (6 responses), being more reliable (6 responses), offering quicker, shorter services (4 responses) and practising good time management (4 responses). While Question 11 related more to a PT waiting room, 5 responses (3.5%) related to improving the queuing system and offering a quicker transport service.

Ignoring the outlier portion from Question 11, an average of **13.4%** of the sample found reliability important. While this is far lower than the average percentage for safety and security, this just shows that safety and security is a higher priority to Gauteng commuters than their services being reliable. Nonetheless, the survey data shows that the level of service quality offered by PT services (including the safety and reliability thereof) has a strong influence on commuter's travel mode selection (Aarhaug & Elvebakk, 2015) and should thus be a key design consideration.

4.3.1.2.1.4 Affordability

In Question 7, a total of 97 participants (11.2%) found their PT service to be too expensive, while 21 participants (9.9%) said in Question 8 that more affordable services would made their travel journey better. No comments relating to affordability were made in Question 11, meaning an average of **10.6%** of the sample found affordability of their PT service important. This asserts that poor service quality can be characterised by issues like expensive service charges (Shaw, 2006; Barrett, 2004) and that some commuters have no other option that their original transport mode because of those alternative modes being too expensive – the 18 participants who claimed they had no choice but to pay more if their PT service became more expensive (Question 6) strongly supports this.

4.3.1.2.1.5 Conclusion

Summing together the average proportions relating to the above three design considerations, an average total of **56.7%** of the sample supported that Gauteng PT services should be safer, more reliable and more affordable. Thus, most Gauteng commuters support PTE2's view that "access to safe, affordable and reliable transport" is currently the highest priority in South Africa's PT provision (PTE2:I23) and that they would want to use a transport service if it is affordable and safe (PTE2:I23). PTE3's view that affordability is the "number 1" need of commuters was not strongly supported by the sample (as only 10.6% expressed their views on the subject), while the reliability and punctuality of transport services were also not shown to be critical (with only 13.4% expressing their views on the subject). The majority of commuters expressed their views regarding the safety and security of their PT service (32.7%), indicating they prioritise feeling safe when using PT above all other travel needs.

Given that over half the sample supported this initial principle, further development thereof is justified. However, what must be kept in mind is that Gauteng commuters prioritise their safety and security more than the reliability, punctuality and affordability of their service.

4.3.1.2.2 Initial PT Principle 2: Provide access to as many commuters as possible to use PT services

Question 24 tested the applicability of this initial principle and was supported by the finding of Questions 7 and 8. A value of $WCPS_{24} = 76.9\%$ was observed for the question, illustrating that over three-quarters of the sample are in support of this principle and thus favour the idea of being able to access all the PT services they want to use. In Question 7, 57 participants (6.6%) said they were unhappy with their PT service because it was difficult to access and 85 participants (9.8%) due to the service not always being available, while 23 participants (10.8%) said in Question 8 that improved availability and accessibility would improve their travel experience. This equates to an average of **9.1%** of the sample expressing their views towards this initial principle.

Due to the amount of support towards this initial principle, it is clear that some commuters are also not able to access regular BRT or MBT services (Barrett, 2004) and that "access to the greatest possible number of people" should be provided (Naude, Jones & Louw, 2005). Furthermore, PTE2's view that "if you're giving people access, that means you've thought about and designed that there's access for everybody" (PTE2:I23) is also confirmed, in addition to PTE1's view that the need of accessibility also strongly relates to considering the needs of the disabled community (PTE1:I5), who often have limited access to PT due to their disabilities; 8.3% of the sample wanted to see disabled facilities in a PT waiting area (Question 9).

Since over three-quarters of the sample supported the applicability of this initial principle, further development thereof is definitely justified. While this may be the case, the portion of participants supporting improved availability and accessibility are lower than all the previous three design

considerations (safety, reliability and affordability), showing that is definitely not a priority for commuters. Nonetheless, given the enormous WCPS value emerging from this initial principle, it should definitely still be a key consideration when designing Gauteng's PT services.

4.3.1.2.3 Initial PT Principle 3: Convenience: connectivity, ease of transfers and ease of interoperability

Question 21 tested the applicability of this initial principle and is supported by the findings of Questions 7 and 8. A value of **$WCPS_{21}$ = 45.7%** was observed for this question, indicating that over half the sample do not support the idea of paying for all the PT services using one card, instead of carrying cash. Before this initial principle can be ruled out, the findings of Questions 7 and 8 are first considered.

In Question 7, 60 participants (6.9%) said that the payment system used in their PT service displeases them. In support of this, one participant commented on the MBT payment system, asking "why do we have to count money for the drivers?". In Question 8, a total of 8 comments (3.8%) were made relating to PT payment systems, asking that better payment systems are provided that include electronic payments and a PT card (5 responses). Others asked that they are informed when transport fares go up (indicating a need for fare convenience), while others preferred paying for a month of PT usage and buying a bus coupon, respectively. Another 2 comments were made relating to this initial principle, where participants asked transport service providers to take shorter routes, while another participant asked for more pick-up and drop-off locations.

Overall, this equates to an average of **3.6%** of the responses in Question 7 and 8 relating to connectivity, ease of transfers and ease of interoperability - this is a relatively small portion of the sample. Because $WCPS_{21}$ < 50%, less than half of the sample resonated with this initial principle, likely having other priorities like safety, reliability and affordability. Thus, PTE2's view that "*ease of interoperability* within an *integrated* transport network" is an equal priority to safe, affordable and reliable transport, and that commuters "will have no problems paying for that as long as they know it *works*…" (PTE2:I23) does not seem to apply to Gauteng's commuters. This could be because, right now, ease of interoperability within an integrated transport network "doesn't exist" (PTE2:I23), and many MBT commuters are still expected to count change for drivers, likely not thinking there could be an easier way to manage fares.

Additionally, common ticket fare systems establish a common ground for operators of different PT modes to integrate their services and share revenue (Nielsen, Nelson & Mulley, 2015; Menckhoff, 2005), but current transport issues in South Africa highlight the lack of integration of the rail with its feeder modes. Formal and informal transport modes continue to compete without the thought of integrating their services, failing to present more effective standards of service delivery (Shaw, 2006).

For this reason, it does not seem feasible to develop this initial principle further, as South Africa has not yet been able to properly integrate its PT system. Thus, many Gauteng commuters may not think connectivity and ease of interoperability is important because they aren't familiar with it and have other more important priorities like safety, reliability and affordability. In turn, this explains why there is such a low interest in integrated PT cards. Nonetheless, the findings of this initial principle can be utilised in the recommendation section of this study, as nearly half of the sample *did* support its applicability, meaning it could be useful as a PT design consideration in Gauteng.

4.3.1.2.4 Initial PT Principle 4: Prioritise network integration

Questions 16, 18, 19, 20 and 21 were used to test the applicability of this initial principle. Averaging the weighting score of each question, a value of **WCPS$_{avg}$ = 55.2%** was observed, implying over half the sample approved of the principle's implementation. As such, it may be stated that over half of Gauteng commuters believe modal integration would satisfy their travel needs (Shaw, 2006) and improve the quality of their travel experience.

4.3.1.2.5 Initial PT Principle 5: Aligning institutional priorities with PT development

Questions 14 and 16 tested the applicability of this initial principle. Omitting the weighting score of Question 14, a value of **WCPS$_{16}$ = 38.61%** was observed. While this may be a low weighting score, it should be noted that 218 participants (69%) agreed that "some transport decisions are based on politics instead of what people [being citizens or commuters] might want". This indicates that most Gauteng commuters feel politics are prioritised above their needs as a customer; one participant even declared that "everything is about politics!". Before ruling out this initial principle due to its low WCPS, the findings of Questions 14 and 16 are first discussed.

4.3.1.2.5.1 Question 14

Over a quarter of the sample (32%) disagree that transport officials make an effort to understand their travel needs and how they can help them, while nearly half the sample (47.1%) agreed. Because the responses to this question were relatively evenly spread between strongly disagree and strongly agree, providing accurate, reliable insights from Question 14's findings does not seem plausible, as the results would be representative of less than half of the sample. Nonetheless, the findings show that nearly half the sample believe Gauteng transport officials make an effort to understand their travel needs and how they can help them.

4.3.1.2.5.2 Discussing the role of political gain

The findings of Question 16 aligns well with the view of PTE3, explaining that with "the upcoming local elections, you will have a stoppage of [PT] services for certain individuals to further their political aims" so that leaders are better recognised (PTE3:I5). Furthermore, HCDE2 explains that municipalities effectively

applying public consultation "don't always last that long" due to the ulterior motives, differing priorities and selfish political agendas of those who come into power at that time (HCDE2:I24). Therefore, the experts interviewed in Phase 1 made it clear that ulterior motives and political gain resulting from PT development is often prioritised over good public consultation and providing commuters with a good PT service.

Literature also supports this view. In context of the Gautrain™ project, the only reason its fundamentally flawed plans went ahead is because the government at the time desired to leave behind a legacy, this while the need to provide safer, more reliable transport to dependent citizens was a far greater national priority (Thomas, 2016). Furthermore, a lack of strong, synergistic and holistic leadership is the primary reason behind the lack of modal integration, policy/plan implementation and meeting commuter needs in South Africa (Van der Westhuizen, 2007; Mostert, 2011; Poliak et al., 2017; Land Transport Authority, 1996; PTE3:I12). Mthimkulu (2017) adds that an effective, well-operated and sophisticated PT systems can be offered only once the political will of government officials and national leaders is aligned with suggested plans and policies, supported by both PTE2 and PTE3 who say political will is the primary means of addressing unmet commuter needs in South Africa (PTE2:I8) and is one of the main reasons for limited growth and development of South Africa's PT system (PTE3:I12).

One of the main steps of modal integration is *organisational* integration, involving assigning responsibility to a public authority to define, coordinate and organise the integration of transport services (Pucher & Kurth, 1995; Poliak et al., 2014). The lack of strong, synergistic and holistic leadership on this part elaborates why modal integration has not yet commenced in South Africa (Van der Westhuizen, 2007; Mostert, 2011; Poliak et al., 2017; Land Transport Authority, 1996). Failure to implement suggested PT initiatives, regulations and policies also limits the objective of integrating these transport systems (Department of Transport, 2021; Turok & Watson, 2001).

4.3.1.2.5.3 Conclusion

It should first be noted than only one survey question with a legitimate WCPS score was used to test this initial principle, suggesting some more accurate context on the applicability of this principle was required to make a more reliable decision of its relevance. While $WCPS_{16} < 50\%$, the findings of Question 16 are strongly supported by literature as well as the views of experts interview in Phase 1. Thus, this initial principle should be considered when developing the final HCPTD principles, but should come second to selected initial principles that were properly tested and possess and reliable WCPS value. Even so, it must be noted that almost half the sample (47.1%) believe Gauteng transport officials make an effort to understand their travel needs and how they can help them.

4.3.1.2.6 Initial PT principle 6: Developing local management structures for PT operations

Questions 18 - 20 tested the applicability of this initial principle, producing an average weighting value of **WCPS$_{avg}$ = 63.9%**. This implies that far over half the sample found this principle perfectly applicable. The questions testing this initial principle are now discussed in context of literature and the expert insights provided in Phase 1, after which a clarifying conclusion on the applicability of this principle is offered. It should be noted that the context of this initial principle relates strongly to **initial PT Principle 4 – Prioritise network integration**, as the presence of local management structures for PT operations are known to be key to getting South Africa's PT network integrated (PTE3:I30; Thomas, 2016). Thus, a similar argument can be expected for this initial principle.

4.3.1.2.6.1 Question 18 – informing commuters of late arrivals

A total of 266 participants (84.1%) agreed that they would like to be informed if their PT service will be late. As discussed in initial PT Principle 4 above, integration of a PT system serves the enhanced provision of travel information, journey planners and trip booking systems, offering real-time information on mode locations (Ibrahim, 2003) through the use of digital mobility applications; these applications must more rapidly respond to the demands and travel habits of commuter (Cohen et al., 2017).

Because the bulk of the sample agreed to Question 18's statement, Gauteng commuters have indicated their support towards the *infrastructure development* step of **physical integration**, wherein electronic travel guides can inform users of minimum travel times (Ibrahim, 2003) and thus also inform them if their transport service will be late. PTE3 recommends that integrated PT control centres are established on a municipal level, wherein busses and taxis feed into rail transport. As such, the timings of feeder services should be synchronised so that feeder services leave punctually and arrive at the train station just before the train leaves. In the event of late arrivals, drivers should be able to communicate with the control centre to inform them of the exception so that the rail service can be held back, and commuters are swiftly informed of any schedule changes (PTE3:I39).

4.3.1.2.6.2 Question 19 – having the option to select an alternative travel mode

In the event a PT service is running unsatisfactorily late, commuters should have the option to select another transport service near them that can take them to their desired destination. Question 19's findings observed that 88% of participants would like to know which other service near them can take them where they want to go in the event their service is running late. As such, a huge portion of the sample approve of PTE3's proposed integrated PT control centre from which all PT vehicles are monitored, managed and communicated with, thus having the potential to inform commuters on an integrated PT application which service near them can take them where they need to go. This control centre requires PT operations to be managed on a local, municipal level (PTE3:I39), which scholars says is imperative (Colin Buchanan and

Partners, 2003; ECMT, 2002; Shaw, 2006) and can give South Africa the same level of inclusive transport management as developed countries (Thomas, 2016).

4.3.1.2.6.3 Question 20 – reporting transport issues

Linking to the idea of an integrated transport control centre and the proposed integrated PT application that is associated with it, a total of 279 participants (88.3%) said they would like to know where to report the problem if the PT service they are using breaks down. With the functionality of this application that is linked to the integrated control centre, either drivers can either communicate with the control centre to inform them of breakdowns (PTE3:I39) or commuters can post a report on the application to make them aware of this. This will allow another PT service vehicle to be sent out immediately to collect waiting passengers and deliver them to their destination, while the broken-down vehicle is towed in for repairs. Even so, one participant asks that any reports made (not necessarily about vehicle breakdowns) are kept anonymous, while another participant declared that it is not their problem if the MBT service breaks down.

These comments shows that the functionality for commuter reports to be made on the proposed application can be applicable to *any* complaint, query or form of self-expression. HCDE3 supports this functionality, explaining that everything in service provision boils down to whether commuters with issues or frustrations feel *heard*, being an "incredibly important" part of providing a proper human-centric service (HCDE3:I21). However, empathy such as this *must* be practical, so if transport authorities aren't going to do something about it, then it's pointless (HCDE3:I3). Literature supports this view, stating that "understanding people's behaviours, thoughts and emotions" (emotional empathy) births an excellent design (Mad Pow, 2021).

In addition, the second comment made shows that Gauteng commuters expect to be treated as customers, meaning it shouldn't be their problem if a PT service breaks down. Thus, PTE3's view that drivers can communicate with the integrated control centre to inform them of breakdowns (PTE3:I39) is supported, as it should be their responsibility as service providers to resolve any exceptions such as vehicle breakdowns and late arrivals, an inform passengers swiftly, likely through the functionality of the integrated PT application.

4.3.1.2.6.4 Conclusion

The findings for Questions 18 – 20 indicate a strong approval of the integrated PT control centre proposed by PTE3. With a value of $WCPS_{avg}$ = 63.9%, it can be said that nearly 64% of Gauteng's commuters would like local management structures for PT operations to be established on a regional and municipal level as it would have the potential to inform them of late arrivals (Question 18), give them the option to select another travel mode if their service is running unsatisfactorily late (Question 19) and allow any report, query or form of self-expression regarding their PT service quality to be posted on the proposed application

(Question 20). The application proposed can be used as means to maintain constant communication between the control centre (which monitors, manages and communicates with all PT vehicles in the network (PTE3:I39)) and users. However, for the purpose of such an application to be even conceivable, PT operations must be first be managed by local transport authorities on a regional, municipal level to create a foundation for local network efficiency, development and management (PTE3:I39).

As explained by PTE3, there is little capacity for the implementation of proposed plans and policies in South Africa, which is where South African transport authorities lack to a great degree (PTE3:I12). New transport infrastructure or policies to improve PT service quality in South Africa are often introduced, but not carried out. This is often due to a lack of leadership to support the system's growth and drive the project to completion (Poliak et al., 2017). Plans and policies require a driving force to implement and create new transport networks (PTE3:I12), and it is only when the political will of government officials and national leaders are aligned with these plans that effective, well-operated and sophisticated PT services can be provided (Mthimkulu, 2017). The inability of authorities to evolve their local PT system limits the potential of these systems, in turn leading to wasted funds that result from duplication of services and the incorrect mode of transport being provided on particular routes (PTE3:I10).

A lack of effective, fully functioning transport authorities also leads to fragmented funding streams and service delivery at local municipal level, as the planning and provision of PT services is managed by several organisations and agencies in an uncoordinated way. As a result, PT modes continue to operate in silos instead of their functions being integrated, resulting in destructive competition between modes that is detrimental to the health of the PT system and leads to additional national funds being wasted (Futshane & Wosiyana, 2005; Walters, 2014; Van de Velde & Sleuwagen, 1997; Geach, 2019).

When there are no fully functioning transport authorities tasked with the planning, management and regulation of PT operations and creating recognition for the importance of PT development in the social and economic development of the country, other national priorities will rise above transportation and will thus receive more funding (Futshane & Wosiyana, 2005), suggesting that PT will not receive enough funds to develop and upgrade its systems. The establishment of proper transport authorities will thus consolidate these fragmented efforts as they are responsible for the overall planning, coordination and regulation of PT, giving South Africa the chance to recognise the importance of PT development, improve local PT service delivery and correctly integrate its modes (Futshane & Wosiyana, 2005).

Scholars strongly support the instantiation of local, regional transport authorities, explaining that these regional structures are imperative (Colin Buchanan & Partners, 2003; ECMT, 2002) for allowing operator behaviour to be managed at a city level (ITDP, 2004), requiring a pro-active approach for local governments to intervene in the provision of infrastructure, regulation of private operators and monitoring service

provision (Shaw, 2006). Executive power to manage a competitive transport environment must also be assigned to local authorities (Chen et al., 2016), while the instantiation of a special purpose transport agency, with a holistic perspective on PT and carrying a reputation of transport improvement, must monitor and manage the movement of all formal transport service operators (Mostert, 2011). PTE2 support the latter view, believing that setting up a "transport authority that's independent of the government changes" is one way of countering fragmented transport provision (PTE2:I9).

South Africa can achieve the same level of inclusive transport management as developed countries by establishing local transport authorities as greater means of modal support and regulation, allowing transport operations to be coordinated locally so the travel needs of citizens can be met more specifically (Thomas, 2016). Considering the massive WCPS value for this initial principle as well as support from literature and Phase 1's experts, further development of the initial principle is definitely justified. Since its context aligns well with initial PT Principle 4, both these principles should be considered when developing the final HCPTD principles.

4.3.1.2.7 Initial PT principle 7: Define the roles and function of every mode

Questions 1 and 2 were used to test the applicability of this initial principle. Because no weighting score could be assigned to these questions, the applicability of this principle was determined based on the findings for these two questions.

4.3.1.2.7.1 Long-distance trips

Most Gauteng PT users (nearly 60% of the sample) use MBTs for long-distance trips, likely due to its cost-effectiveness and not having another travel alternative. In fact, Question 6 captured 18 participant responses stating that they had no choice to pay more for their PT service if it became more expensive – most of these participants were MBT users. This suggests that commuters use taxis because they are affordable and continue to use the service even if it becomes more expensive because they cannot afford MaaS or another PT alternative. Literature supports this notion, stating that MBTs possess an effective business modal that reaches potential passengers simply and conveniently. Thus, other modes can learn from the informal way in which MBT networks meet customer demands by providing a frequent, accessible and flexible transport services (Walters, 2014; Mthimkulu, 2017).

One participant mentioned they use the taxis because they are convenient; this is supported by Walters (2014) and Mthimkulu (2017). However, several participants mentioned that they as users were expected to count money and give change to each customer if they sat nearby the driver – there was rarely an MBT assistant there to do this. These participants found it tedious and ridiculous that they needed to give other customers change when they were *also* customers of the service, asking "why do *we* need to count money for the drivers?". In addition, some participants said that many a time, seatbelts are not provided on MBT

vehicles; in fact, one participant completed a survey just after having been released from hospital due to a taxi accident he was in.

Literature explains the concerns of the sample's participants. Every day, MBT owners set challenging minimum target earnings for their drivers, implying drivers earn any earnings in excess of this target. Thus, it seems MBT drivers are distracted by the need to maximise their daily earnings by ignoring traffic regulations and taking risks on the roads (Walters, 2014; Khosa, 1998), thus loosing sight of the importance of good customer service. A total of 29 comments in Question 8 (13.6%) were made requesting better customer service, asking taxi drivers to have more respect for their customers (9 responses) and that good customer focus (8 comments) and more polite drivers (6 responses) would better their travel experience. Averaging the weighting scores for initial HCD Principles 2, 3, 4 and 6 (which were considered when developing the final HCPTD principles) produced a **WCPS$_{HCD\ total\ avg}$ = 56.6%**, clearly illustrating that well over half of Gauteng's commuters supported the applicability of HCD principles.

These results strongly emphasise that Gauteng PT users desire a more human-centric service delivery when using PT (particularly MBTs), asking to be treated more respectfully, politely and professionally by PT operators. The HCD process is driven by the needs and aims of the person using the proposed product or service, instead of the organisation's goals (Norman & Draper, 1986; Rogers, Sharp & Preece, 2015), aiming to create products that align with the personal preferences of the user and thus cultivate a mood of support, collaboration and personal connection (Thomsen, 2018). Thus, it is clear Gauteng PT users are not receiving such a service even when they strongly desire it (WCPS$_{HCD\ total\ avg}$ = 56.6%).

Given the **35.4% shift** from taxis towards private cars and MaaS, this comparison may stand as evidence that most MBT users would actually prefer using a private car, MaaS or a bus for their long-distance trips due to its comfort, convenience and the good customer service received. Additionally, 18 participants shared in Question 6 that they had no choice but to pay more if their PT service becomes more expensive, clearly demonstrating that some Gauteng commuters are held captive to their unethical, unreliable PT services because they don't have more to spend – literature supports this view (Lombard and Hugo, 2002; Oxford, 2013; Mthimkulu, 2017; Thomas, 2016). Furthermore, one participant mentioned that they would prefer using Bolt™ because they have personal space, while another said they would rather use Uber™ if taxi fares go up. Nonetheless, nearly a quarter of Gauteng commuters (24.4%) still prefer using taxis for long-distance trips, suggesting they are satisfied with the service they receive and would prefer the service they currently use if they had a choice.

4.3.1.2.7.2 Medium-distance trips

When considering medium-distance trips, just over half the sample (50.8%) use MBT services and just over a quarter of the sample (25.9%) used private cars or MaaS. This again emphasises that most commuters

use MBT services even for medium-distance trips due to their convenience and cost-effectiveness as was discussed above. However, when it came to their *preference*, 43% preferred using the private car/MaaS and 29.9% preferred the taxi; thus, when it came to preference, the transport roles reversed.

The significant shift from taxis (**20.9%**) shows that many MBT customers would prefer using other modes of transport over such as private vehicles/MaaS (43%), NMT (15.6%) and buses (6.7%) over the MBT service because their increased comfort, convenience, good customer service and increased safety. One participant stated in Question 2 that "Ubers are better than taxis", while another expressed in Question 5 that they want their own car. Furthermore, participants in Question 6 said that they wouldn't pay more to use a PT service if it became more expensive and would rather use a Bolt™ because they have personal space, supported by another participant who also disagreed because they "would rather use Uber™". The low preference of bus use for medium trips was explained by one participant stating, "Buses take longer", showing travel time and transfer time was more important to commuters than the comfort and safety the buses offered.

Given the discussion presented in the section above, this could also imply that some MBT users are still held captive to that service because they don't have more to spend on transportation (Lombard & Hugo, 2002; Oxford, 2013; Mthimkulu, 2017; Thomas, 2016), thus not having the option to experience more comfort and better customer care in their travels even if they desire it. This is emphasised by the 18 participants in Question 6 who said they had no choice but to pay more to use a PT service if it became more expensive.

4.3.1.2.7.3 Short-distance trips

While MaaS is preferred over MBT services for short-distance trips (25% versus 11.5%), only a small proportion (**9.7%**) shifted away from NMT to other modes when asked for their preference. This is a strong indication that NMT infrastructure of improved quality and safety should be provided alongside PT routes, as most Gauteng PT users would prefer using NMT to travel short distances: whether they had a choice or not.

4.3.1.2.7.4 Conclusion

Table 19 summarises the top two results for *current* PT use versus PT *preferences*. Since private cars/MaaS were preferred for both long- and medium-distance trips, it is made clear that many commuters prefer enhanced comfort, safety and customer service, but do not have access to it because their funds are limited. In relation to customer service, participants emphasised in Question 7 that they are frustrated with the MBT service because they are expected to give change to other customers, get sworn at by drivers in many languages and feel unsafe or uncomfortable using the taxi because drivers don't follow road rules, vehicle doors are broken, and taxis are packed to the brim to maximise driver earnings. Thus, they are held

captive to the taxi service due to its relatively low fares and the convenience it brings them, but actually prefer using a private car, MaaS or bus to make long- and medium-distance trips.

Moreover, the minor shift in NMT use like walking, cycling and skating when commuters were given a choice (9.7%) illustrates that Gauteng PT users would prefer using NMT for their short-distance trips whether they had a choice or not. Thus, Gauteng's PT network must provide for the huge proportion of commuters (at least 58%) that want to walk, cycle or skate to cover short distances, as cities that have made a bigger investment in higher quality PT systems can provide suitable urban environments for pedestrians and cyclists (Kenworthy, 2006): the most sustainable ways to travel (Newman & Kenworthy, 1984).

While above insights are useful considerations for Gauteng's PT design, they do not provide enough data to support the applicability of this initial principle. Testing such a complex principle amongst commuters was difficult to achieve, as commuters are not familiar with the *roles* of each mode in PT design but only the *service* they receive. While there is a great deal of expert- and literature support for the applicability of this principle, reinforcing it with commuter survey data was not possible in this study as commuters could not relate to the technicality of the principle. Thus, it does not seem feasible to develop this initial principle further because an insufficient amount of survey data was available to reinforce its significance. Nonetheless, the findings from this principle can still be considered in the study's recommendations section.

It must however be noted that this principle relates strongly to modal integration (initial PT Principles 4 and 6), since defining the roles and function of every mode in the network (Naude, Jones & Louw, 2005), allows different travel corridors and passenger volumes to be served (Department of Transport, 1998) and can thus have the potential to balance and integrate the network by introducing high-capacity BRT services on major arterials. In turn, this would allow an efficient trunk-and-feeder system to be constructed in cities where automobiles and MBTs used to dominate (ITDP, 2004) where every mode in the urban transport network has a very specific role to play (Department of Transport, 1998). Thus, if modal integration is shown to be key commuter desire from the initial principles chosen, defining the roles and function of each mode will eventually become a key design consideration to promote network integration.

Table 19: Comparison between current transport use and preferences

Type of trip	Current transport used	Preferred transport
Long trip	Taxi (59.8%) Bus (21.6%)	Private car/MaaS (36.2%) Bus (29.8%)
Medium trip	Taxi (50.8%) Private car/MaaS (25.9%)	Private car/MaaS (43%) Taxi (29.9%)

| Short trip | NMT (67.7%) | NMT (58%) |
| | Taxis (17.6%) | Private car/MaaS (25%) |

4.3.1.2.8 Initial PT principle 8: Promote collaboration and interaction between various stakeholders

Question 12, 13, and 22 and 23 were used to test the applicability of this initial principle amongst Gauteng commuters. Averaging the weighting scores for these questions, an average value of **WCPS$_{avg}$ = 58.3%** was observed, implying well over half of Gauteng's commuters believe this initial principle is perfectly applicable. To further investigate its applicability and support from literature, each of the above survey questions were discussed.

4.3.1.2.8.1 Questions 12 and 13

In Question 12, 79.9% of the sample agreed that they would like the opportunity to give their ideas and create the transport service they use, while in Question 13, 82.9% of the sample agreed that they would be more interested in using PT if their inputs were used to improve the service they use. These findings clearly illustrate that Gauteng commuters want to be included in the design of PT services and offer their ideas and feedback, thus supporting HCDE2's view that elevated customer satisfaction in South African transport can be offered by building in stakeholder's consultation into the PT design model (HCDE2:I42) and that authorities "set up negotiating forums, some sort of space where the authorities and the people they are making decisions on behalf of have a regular engagement" (HCDE2:I32).

4.3.1.2.8.2 Questions 22 and 23

In Question 22, 84.5% of the sample responded positively to the idea of transport officials making a regular effort to understand their travel needs and how they can help them. Moreover, in Question 23, 81.3% of the sample responded positively to transport officials involving them when creating a PT service. Thus, the sample responded positively to the concept of monthly negotiating forums (HCDE2:I32), stakeholder's consultation in the PT design model (HCDE2:I42) and being able to express themselves to a human-centric professional that is tasked to talk to customers, listen to their needs and understand what is important to them (PTE2:I26).

4.3.1.2.8.3 Conclusion

The findings of Questions 12, 13, 22 and 23 demonstrate that most of Gauteng's commuters (**58.3%**) believe this principle is perfectly applicable. Thus, the bulk of Gauteng's commuters would like to be involved in

the PT design process through regular public stakeholder consultation (HCDE2:I42) and monthly negotiating forums (HCDE2:I32), while being able to express their concerns and needs to human-centric professionals on a PT design team (PTE2:I26).

Literature supports the benefits of public consultation in a PT design process, allowing cities to reach smart city standards by working together with citizens and institutions who are knowledgeable of the history, culture and probable future of the city (Lara et al., 2016). The human infrastructure domain of a smart city can be enhanced by involving citizens in the joint design and implementation of services within the city, encouraging and allowing citizens to participate in the construction of infrastructure as well as gathering and utilising continual feedback on its effectiveness in meeting their needs (Rizzo, et al. 2013). In fact, to make a city and community "smart", all initiatives must comprise of an iterative, user-centric process where the community is involved in design and development (Lara et al., 2016).

Thus, literature and expert insights assert that incorporating stakeholder consultation into South Africa's PT model is *crucial* for its current development, allowing a spectrum of different stakeholders (including commuters, scientists, authorities and psychologists) to contribute their unique perspectives to designing a PT system with the central goal of serving the needs of the city and its people (Pillay, 2001; Zellner, 2008; Yigitcanlar et al., 2016; PTE2:I26; HCDE2:I32; HCDE2:I42). Therefore, the further development of this initial principle's context is definitely justified, and it should be used when creating the final HCPTD principles.

4.3.1.3 *Discussion of correlation analysis*

As shown in Figure 33, a Pearson Correlation Coefficient of *r = 0.982* was determined. This implies that the presence of HCD measures in Gauteng PT services are 96.4% correlated to commuter satisfaction with and desirability for PT service use (Bold, 2001; Leedy & Ormrod, 2005; Cooper & Schindler, 2001), thus having a strong positive correlation. For this reason, it can be concluded that including more HCD measures in Gauteng's PT services will indeed result in increased commuter satisfaction and desire to use these services, in turn improving the operational success of these service. Notably, such a high *r* emerged even when three outlier question combinations were included in the analysis, showing that a strong correlation between these variables remain.

The auto-correlation questions (Question 10 and 13) both displayed weighting scores well above zero, namely 170 and 356. This shows that, overall, Gauteng commuters *would* pay more to use a PT service if they saw the items they selected in the proposed waiting room and would be more interested in using PT if their inputs were used to improve the service they use. Literature asserts that these measures do indeed indicate a presence of HCD measures, as HCD ultimately designs services, products or systems tailor-fitted to meet the central needs of those who are faced with a problem (Design Kit, 2021; DC Design, 2017) and creates products that align with the personal preferences of the user, cultivating a mood of support,

collaboration and personal connection (Thomsen, 2018). The above provides further support for the presence of HCD measures in Gauteng's PT design, as these questions tested the Variable A-Variable B correlation automatically.

4.3.1.4 *Discussion on the minibus taxi industry*

4.3.1.4.1 Introduction

Qualitative interview theme 4 (section 4.1.4.3) considers how MBTs dominate the PT system in South Africa. While this does not influence the provision of the final HCPTD principles, a brief discussion on its relevance is offered to link expert insights to literature and the survey data obtained, as much has been said about its impact of the MBT industry on local PT development.

4.3.1.4.2 Expert interview insights

When asked to provide improvements to bring about elevated customer satisfaction in South African PT, HCDE2 claimed resolving the issue of taxi violence is crucial, believing it is a "very big thing that causes a lot of the other problems". Besides the recommendation to build stakeholder's consultation into the PT design model, HCDE2 suspects that "technically, all the issues are there." (HCDE2:I42) The issue with the rail and bus services is that "the taxi industry has sabotaged them totally", resulting in competition between the sectors – this is why we "need to solve the taxi industry issue." (HCDE2:I43) "The reason there is so much [taxi] violence is because there's so much competition", as "every other form of transport is a threat to the existing industry". This "kind of lawlessness which is there in general" is "is not conducive to a good sector. So resolving the issue of violence is a *must*." (HCDE2:I20)

Due to the taxi violence and route disputes they cause, HCDE3 believes MBTs are an external factor affecting the success of South African transport systems (HCDE3:I18), while PTE3 believes "intimidation" from the taxi industry limits the growth and development of South Africa's PT system (PTE3:I12). PTE2 strongly believes that "i[f] we [(South Africa)] form and constitute proper and effective transport authorities, then we have to legislate and regulate the taxi industry. There's no buts about that. They need to be brought into a formal, subsidised arena. They have to be regulated." (PTE2:I10) Relating to MBTs, HCDE2 explains "it's a completely lawless industry" (HCDE2:I15) as taxi drivers "have no protection whatsoever" and can only get protection if they are regulated in some way (HCDE2:I7). While "there is existing regulation, compliance with that will be a pretty good start." (HCDE2:I22).

4.3.1.4.3 Literature support

Literature supports these views, asserting that only cities practising proper control over the enforcement and regulation of transport service operators have found success in transport infrastructure upgrades (Fourie, 2003), and that the inability to effectively regulate the detrimental competitive practises of these informal modes has been a reason why South Africa has struggled to develop its PT systems and encourage

increased ridership (Shaw, 2006). Municipalities first need to collaborate with and then redistribute MBT drivers to BRT vehicles in order to exercise BRT development, suggesting challenges exist with negotiating and reassigning MBT drivers without conflict (Walters, 2013). However, there seems to almost be a deliberate attempt by various modes to avoid modal integration, likely because of the complications it would present for their payment systems and operational freedom (Brand South Africa, 2015). It seems formal and informal transport modes continue to compete without the thought of integrating their services, failing to present more effective standards of service delivery (Shaw, 2006).

4.3.1.4.4 Conclusion

Both Gauteng experts and global literature have stressed the importance of addressing MBT violence and lack of regulation due to the way it adversely affects the health and development of Gauteng's PT system. As such, it is clear that proper enforcement and regulation of the MBT industry is necessary in the GP in order for its PT systems to become more developed and promote modal network integration. By resolving issues relating to the MBT industry, HCDE2 believes the demand for transport can be "more freely distributed across the different kinds of transport", likely offering a change in the transport system where "taxis have a different role" to play. This type of balance can only be created through negotiations between the different transport parties (HCDE2:I43). Thus, one primary way of addressing the MBT issue is effectively applying HCPTD Principle 1 to Gauteng's transport context.

PTE3 says that the taxi industry needs more exposure, training and understanding of business moving forward in order to form part of the upcoming integrated PT system (PTE3:I19). Question 8's findings shows that 13.6% of the sample requested better customer services, asking taxi drivers to be more respectful to their passengers and more polite. One participant even said that "taxi drivers need training with respect to customer service". Effective application of HCPTD Principle 3, 4 and 5 is recommended to aid the MBT industry in providing more human-centric service provision.

4.3.2 Selecting most apt initial principles

4.3.2.1 Summary of discussion

Based on the discussion in section 4.3.1, Table 20 summarises the initial principles selected that were used to develop the final HCPTD principles. The chosen principles were ranked according to the WCPS values determined for them. Notably, a WCPS score could not be calculated for initial HCD Principle 5 but it was chosen to be developed further, due to the strong correlation demonstrated in this principle, its applicability thus being strongly supported by the survey data.

While initial HCD Principle 7 was considered unfeasible to develop further, it was included in Table 20 as nearly half the sample supported its applicability. Initial PT Principles 3, 5 and 7 were deemed unfeasible to develop further due to their low WCPS values, but are still considered in the study's recommendations

section. Since insufficient survey data was available to prove the applicability of initial PT Principle 7, a decision was made to include initial PT Principle 3 in Table 20 due to it having a higher WCPS score than initial PT Principle 5.

Table 20: Summary of initial HCD principles selected

Rating	Initial principle with definition	WCPS value (%)	Rating	Initial principle with definition	WCPS value (%)
1	**Initial HCD Principle 3** - *Centralise people's needs, desires and feedback in the design process*	58.6	1	**Initial PT Principle 2** – *Provide access to as many commuters as possible to use PT services*	76.9
2	**Initial HCD Principle 6** - *Collaboration and consultation with stakeholders*	58.3	2	**Initial PT Principle 6** – *Developing local management structures for PT operations*	63.9
3	**Initial HCD Principle 4** - *Practical empathy*	55.3	3	**Initial PT Principle 8** –	58.3

				Promote collaboration and interaction between various stakeholders	
4	**Initial HCD Principle 2** – *Consider the entire ecosystem*	54.3	4	**Initial PT Principle 1** – *Prioritise safe, reliable and affordable transport services*	56.7
5	**Initial HCD Principle 5** - *Enhance a commuter's perceived value when designing*	-	5	**Initial PT Principle 4** – *Prioritise network integration*	55.2
6	**Initial HCD Principle 7** – *People-centred development*	46.4	6	**Initial PT Principle 3** – *Convenience: connectivity, ease of transfers and ease of interoperability*	45.7

4.3.2.2 *Selecting matching principles*

In order to begin developing the final HCPTD Principles, matching principles of HCD- and PT design from Table 20 must first be selected. The idea is to combine together a related principle from either study construct and create a HCPTD principle by integrating the information relevant to each principle included. Table 21 summarises the selected principles that were matched together. Initial **HCD Principle 6** was matched with initial **PT Principle 8** because both related to the public consultation, interaction and collaboration; these principles also had a similar WCPS value.

The development of a local integrated PT control centre should arguably also involve a consideration of the entire local ecosystem that surrounds it, as the control centre should monitors, manages and communicates with all PT vehicles in the network (PTE3:I39) and thus understand how people are moving in that region. As such, initial **HCD Principle 2** was matched with initial **PT Principle 6**.

Since an average of **32.7%** of the sample expressed views regarding the safety and security of their PT services (the highest proportion noted for all the travel needs indicated), it is important for Gauteng PT service providers to empathise with this need to understand what Gauteng PT users experience every day. For this reason, initial **HCD Principle 2** was matched with initial **PT Principle 1**.

Considering Table 18, it should be noted that initial HCD Principle 3 and initial PT Principle 4 tested four of the same questions. In the discussion section, it was noted that participants supported the concepts of **physical** integration (integrated PT application and control centre) and **operational** integration (common

ticketing systems), arguably because its instantiation would centralise their needs, desires and feedback in the design process. In Question 19, a total of 266 participants (88%) agreed that if their PT service is running late, they would like to know which other service near them can take them where they want to go, while in Question 20, a total of 279 participants (88.3%) said they would like to know where to report the problem if the PT service they are using breaks down.

With 70.3% of the sample in Question 21 agreeing to pay for all their PT services using only one card, a desire for an electronic payment system in Gauteng's PT service is also being demonstrated. Participant comments indicate that Gauteng PT users are frustrated with the current payment system employed in these services, often involving working with change and being expected to give all customers change while also being a passenger. An electronic payment system would be far more human-centric in the sense that people can simply tap their PT smart cards to pay (Ibrahim, 2003; Fang & Zimmerman, 2015) instead of having to manage notes and coins (especially during COVID-19). Because of the massive support shown for HCD concepts such as understanding the perspective and central needs of those who are faced with a problem and designing services tailor-fitted to meet those needs (Design Kit, 2021; DC Design, 2017) and understanding how the product can be better designed to align with people's needs and expectations (Thomsen, 2018), initial **HCD Principle 3** was matched with initial **PT Principle 4**.

The remaining two principles (initial **HCD Principle 5** and initial **PT Principle 2**) were then matched with one another, as it seems very likely that a commuter's sense of perceived value can be enhanced if over *three-quarters* (76.9%) of Gauteng adult commuters believe providing access to as many commuters as possible is perfectly applicable to them.

Table 21: Matching HCD- and PT principles selected from discussion

HCPTD principle number	Selected HCD principle with definition	WCPS value (%)	Selected PT principle with definition	WCPS value (%)
1	**Initial HCD Principle 6** - *Collaboration and consultation with stakeholders*	58.3	**Initial PT Principle 8** – *Promote collaboration and interaction between various stakeholders*	58.3
2	**Initial HCD Principle 2** – *Consider the entire ecosystem*	54.3	**Initial PT Principle 6** – *Developing local management structures for PT operations*	63.9
3	**Initial HCD Principle 4** - *Practical empathy*	55.3	**Initial PT Principle 1** –	56.7

			Prioritise safe, reliable and affordable transport services	
4	**Initial HCD Principle 3** - *Centralise people's needs, desires and feedback in the design process*	58.6	**Initial PT Principle 4** – *Prioritise network integration*	55.2
5	**Initial HCD Principle 5** - *Enhance a commuter's perceived value when designing*	-	**Initial PT Principle 2** – *Provide access to as many commuters as possible to use PT services*	76.9

4.3.3 Presenting the final principles

4.3.3.1 *Introduction*

Discussions were offered in section 4.3.1 that considered the applicability of each initial principle, while section 4.3.2.2 and Table 21 discussed why selected principles were matched with one another. Integrating related and relevant principles of HCD- and PT design has produced five final HCPTD Principles, which are the most relevant to Gauteng PT users and capable of enhance their satisfaction with the services they use. In addition, these principles provide a platform for public engagement and act as a mechanism for the voices of customers to be heard and incorporated into PT design. These final HCPTD principles can provide Gauteng's transport authorities and modal service operators with the knowledge necessary to incorporate HCD into their PT service provision.

4.3.3.2 *How the principles were developed*

Arguments for why the selected initial principles were matched were offered in section 4.3.2.2. The context of the matched principles were now integrated into five **final HCPTD Principles** by blending all information, study findings and literature applicable to the matched principles. From this point onwards, the WCPS values are not applicable. The content from related principles were blended together in such a way that they are simple to follow and useful for Gauteng's PT designers, summarising key study findings to support their validity and provide guidance from Phase 1's experts where necessary.

4.3.3.3 *Final human-centric public transport design principles*

Having discussed the applicability of each one of the initial principles selected, Table 22 summarises the definition, insights and general guidelines for each of the five HCPTD principles. The relationship between the five HCPTD Principles is illustrated by Addendum H. Please note the colour key linked to each HCPTD Principle (P). Notably, for HCPTD Principle 5, improved safety and reliability was also included as a means to improve a commuter's perceived value of that service. This is because most participant responses from Phase 2 related to safety (32.7%) and reliability (13.4%), but initial PT Principle 2 achieved the highest WCPS value of all travel considerations so it also had to be included in HCPTD Principle 5.

The term "ecosystem" was suggested by HCDE3, who says it is crucial to consider issues in the *entire* transport ecosystem (HCDE3:I19) when designing PT services. HCDE1 also say it is important to get insights from the entire ecosystem of customers to understand what they really desire (HCDE1:I2). Scholars explain that in HCD, one should "think of everything as a system" (Babich, 2018) and "focus upon the entire activity under consideration, not just isolated components", as "activities do not exist in isolation: they are components of complex sociotechnical systems" (jnd.org, 2019). Therefore, the term "environment" is a synonym for "ecosystem".

Table 22: Final HCPTD Principles

HCPTD Principle 1 – *Promote collaboration and consultation between various transport stakeholders*
Incorporating authentic, collaborative stakeholder consultation into Gauteng's PT design model enhances commuter satisfaction Provide monthly negotiating forums where authorities and commuters can have a regular engagement Include human-centric professionals on PT design teams to listen to customer needs and understand what is important to them
HCPTD Principle 2 – *Consider the entire transport ecosystem when developing local management structures for public transport operations*
Consider the entire ecosystem around PT services during design Establish integrated PT control centres at local, municipal or regional level: - Promotes network integration   - Linked to an integrated PT application for commuters   - MBTs and BRT act as feeder services for rail transport with synchronised timings   - Electronically monitors, manages and communicates with PT vehicles in the network   - Drivers communicate with the centre in the event of breakdowns or late arrivals   - Commuters are informed swiftly of any service exceptions   Setting up a transport authority that's independent of government changes can counter fragmented transport provision
HCPTD Principle 3 – *Practically empathise with commuters by prioritising safe, reliable and affordable transport services*
Practical empathy of commuter travel experiences develops excellent transport designs that are desirable to commuters Access to safe, affordable and reliable transport is currently Gauteng's highest transport priority
HCPTD Principle 4 – *Transport network integration involves centralising people's needs, desires and feedback in the design process*
Centralise human needs, desires and feedback in Gauteng's PT design process A greater desire to use PT services results from listening and acting on commuter's concerns and suggestions Establish integrated PT control centres, integrated PT applications and common modal ticketing systems
HCPTD Principle 5 – *Enhance a commuter's perceived value by providing for core travel needs*
Perception (emotion) ∝ Desire (enjoyment) ∝ Value (willingness to pay) Improved PT availability, access, safety and reliability improves the perceived value of these service

Chapter 5 Conclusion

5.1 Introduction

The first phase of research began by conducting three semi-structured qualitative interviews with HCD experts and PT experts, respectively, after which an in-depth qualitative content analysis was implemented. By organising the content from these interviews, all qualitative data was sorted into 12 qualitative subthemes and further arranged into four main qualitative themes. In order to make these themes useful and testable, a list of seven initial HCD principles and eight initial PT principles were developed by integrating expert insights with literature.

In the second phase of research, a two-page qualitative correlation-based survey was developed to test the applicability of each of the initial principles developed. After collecting a total 316 surveys from adult PT users in Gauteng, the survey data was analysed and interpreted using weighting scores that emerged from each question to estimate how applicable Gauteng PT users found each of the initial principles in their daily travel experience. After averaging the weighting scores for the questions that tested each principle and discussing the findings for each principle in context of literature and the expert insights obtained in Phase 1, five initial principles were selected from either study construct (namely, HCD or PT) based on how relevant they were to Gauteng commuters. Initial principles were thus selected based on what would enhance the satisfaction of Gauteng PT users and offer the incorporation of HCD into Gauteng's PT design in a way that would best resonate with the humans being designed for – Gauteng PT users.

The five HCD- and PT principles selected were matched up based on how strongly their contexts, associated survey questions and weighting scores related. After creating five matches, five HCPTD principles were presented based on the discussions conducted in section 4.3. These principles are most relevant to Gauteng PT users and capable of enhancing customer satisfaction with the PT they use, while also providing them with an opportunity to participate in Gauteng PT design by having their views, feedback and concerns considered. In addition, these principles provide a platform for public engagement and act as a mechanism for the voices of customers to be heard and incorporated into PT design, providing Gauteng's transport authorities and modal service operators with the knowledge necessary to incorporate HCD into their PT service provision.

5.2 Challenges faced

The main challenge faced in this research study was obtaining ethical clearance to collect data in Phase 1 and Phase 2. The researcher only became aware of this requirement while well into the research, so an extreme learning curve was needed to submit the documents, arguments and administration to obtain ethical clearance in time. Due to a few misunderstandings, poor planning and factors beyond the control of the research, this process extended far longer than was necessary, thus imposing more pressure to finish the two-phased data collection efforts so that the study could be finished on-time and at the level of academic rigor desired.

Another huge challenge faced was the lack of availability of funds to conduct data collection. Since the researcher is a bursary student, Phase 2 of data collection had to commence over two weeks later than was planned because the researcher could not fund the data collection effort. This also linked strongly to the data collection sites that could be accessed, as the researcher had limited funds available and needed to arrange how to collect data in a convenient yet affordable way; this is one reason why data could not be collected outside of Johannesburg, as the researcher could simply not afford it. The limited time that was available after a relatively tedious ethical clearance process also impacted how much time was available to collect data, thus limiting the number of sites and area where data could be collected.

Since the researcher is quantitively inclined, another challenge faced was the complex qualitative thematic analysis implemented in Phase 1. Being more conceptual and less definitive, this process was found to be a great challenge. The decision to do a mixed-methods study also ended up being an enormous challenge, as the researcher had never undertaken such an extensive, multi-facetted and technical study. Because a sequential study was chosen, data had to be collected in two distinctive phases, meaning two ethical applications had to be submitted in which a huge misunderstanding occurred that cost the researcher valuable time. Phase 2 could also not begin once Phase 1 was fully analysed as its design depended on the latter, while the reporting of one phase relative to the results of the other was tedious and often confusing.

Lastly, great strides were taken during a very challenging week of survey data collection. The researcher and DCA endured a great deal of rejection, drama and vulnerable circumstances while collecting data in Johannesburg, *thrice* being asked to leave an area because permission was required from management to collect data. Also, because data was collected in COVID-19, additional efforts had to be made to encourage commuters to participate, as commuters' fear of virus transmission and reluctance to share private information on the COVID-19 contact register *and* complete an informed consent form induced doubt in many prospective participants. Only two people were available to sanitise 308 laminated survey sheets and markers, *and* get participants to complete the register and informed consent form for every one of these responses – this was quite challenging and demanding.

5.3 Research findings

5.3.1 Final human-centric public transport design principles

Of the 15 initial principles developed in Phase 1, only 10 principles were considered when compiling these HCPTD principles, where matching principles were merged to present a single HCPTD principle. Most Gauteng commuters emphasised a need to participate publicly in the design of PT services, resonating with the instantiation of stakeholder consultation, monthly negotiating forums and the inclusion of HCD professionals in PT design teams. All of these human-centric interventions would allow commuters to share their views and create the PT service they use, while having the opportunity to share their feedback and concerns and be heard by transport authorities.

The entire ecosystem surrounding transport infrastructure must be considered when designing PT services, as most Gauteng commuters express that poor PT services negatively affects their lifestyle and their jobs. Furthermore, commuters support the notion that PT services are managed locally (either regionally or municipally) by establishing integrated PT control centres that are linked to an integrated PT application. These measures would simplify and improve commuter travel experiences by informing them of exceptions such as breakdowns and late arrivals. Associated with this need, creating local transport authorities that are independent of government changes is known to counter fragmented transport provision.

Gauteng commuters have confirmed that transport designs would be more desirable for them if transport officials find a practical way to empathise with their travel needs, and travel experience. The survey findings show that most of Gauteng's PT users are most dissatisfied with their PT experience due to the lack of safety and security (both at transport hubs and while using services), followed by poor reliability, expensive transport fares, poor accessibility and inconvenient services. Most of Gauteng's commuters assert that modal network integration should be prioritised so that travel benefits can be reaped from the creation of integrated PT applications, common ticketing systems and the establishment of integrated PT control centres.

One of the key findings in this study is that a commuter's *perception* of a service (how they *feel*) directly affects they extent to which they *desire* (or *enjoy using*) that service and, in turn, their *value* of that service (how much they are willing to *pay*). Due to a weighting score over double that of the latter, the survey data shows that commuters will pay over twice as much if they value a service more. In order to improve the perceived value of a PT service, Gauteng PT services must be (in order of importance) safer and more secure, more reliable, more cost-effective and increasingly available and accessible.

In reference to this directly proportional relationship, it should be noted that one commuter's expectations, requirements and thus perceptions of a PT service may differ from another, meaning the degree to which

they desire or value a PT service may differ. Because all commuters are different, they may have a diverse set of differing needs (both within a specific mode, on the same transport corridor and across different modes) that may affect the extent to which a PT service fulfils their needs. Thus, one explanation for the absence of the human-centric element during the planning, design and operations of South African PT are that commuters have different requirements and expectations of the PT service they use. Because of this, transport service providers may struggle to provide an attractive service that is valuable to their varying customer base, while also being affordable and practical according to their own capabilities.

As such, in order for the developed HCPTD principles to be effective in Gauteng, they must utilised such that they gather, consider and address the needs of *all* their patrons to the furthest extent possible and apply them so that these unique needs are incorporated into the planning, design and operation of PT. A suggestion to do so relates to HCPTD Principle 1 and 4, involving the incorporation of authentic, collaborative stakeholder consultation into Gauteng's PT design, providing monthly negotiating forums where authorities and commuters can have a regular engagement, including human-centric professionals on PT design teams to listen to customer needs and centralising human needs, desires and feedback in Gauteng's PT design process and acting on commuter's concerns and suggestions.

5.3.2 Correlation analysis

A Pearson Correlation Coefficient of $r = 0.982$ was determined between Variable A and Variable B, while large positive weighting scores emerged from the auto-correlation questions. Thus, it can be concluded that including more HCD measures in Gauteng's PT services will indeed result in increased commuter satisfaction and desire to use these services, in turn improving the operational success of these services. Because perception was proved to be directly proportional to value, Gauteng commuter will pay more for PT services if they are more satisfied with (or have a positive perception of) these services. Therefore, if Gauteng PT authorities would like to encourage more commuters to make use of PT services (desire) and obtain increased funds from these services (value), utilising the findings of the five HCPTD principles is key to increasing customer satisfaction (perception) and desirability for these services.

5.3.3 Minibus taxi considerations

Gauteng experts, global literature and survey participants have stressed the importance of addressing MBT violence and lack of regulation due to the way it adversely affects the health and development of Gauteng's PT system. Thus, proper enforcement and regulation of the MBT industry is necessary in the GP in order for its PT systems to become more developed and promote modal network integration. Only by resolving issues relating to the MBT industry can the demand for transport can be "more freely distributed across the different kinds of transport", likely offering a change in the transport system where "taxis have a different role" to play. Negotiations between the different transport parties is the only means of providing

such a balance between transport modes in Gauteng (HCDE2:I43). Thus, one primary way of addressing the MBT issue is effectively applying HCPTD Principle 1 to Gauteng's transport context.

Moreover, the taxi industry needs more exposure, training and understanding of business moving forward in order to form part of the upcoming integrated PT system (PTE3:I19); 13.6% of the sample requested better customer services in Question 8. Effective application of HCPTD Principle 3, 4 and 5 is recommended to aid the MBT industry in providing more human-centric service provision.

5.4 Validity of the findings

According to Godambe (1982), it is critically important to ensure the people chosen have both the necessary understanding and expertise to be part of the sample in order for the findings to be accurate and reliable. The term *validity* describes the degree to which the expected results vary from the observed information (Louangrath, 2015), meaning a study's findings are valid if the results are either the same or vary to a small degree from the observed information.

Aspects relating to the internal- and external validity of a study are discussed by Fink (2003), Price and Murnan (2004) and Price et al. (2004) in section 3.5.2. In Phase 2's survey data collection, a great deal of effort was made to help participants feel comfortable and well-informed before completing a survey response. In situations where participants could not understand English, the DCA translated all relevant study information and often stood by the participants to help them complete survey. It was, however, not possible to control whether socially acceptable survey responses were obtained. Given the careful, focused effort made to consider all these aspects, the study's findings can be considered to have internal validity, thus truly reflecting the views of participant about the study topic (Fink, 2003; Price & Murnan, 2004).

An expert- and snowball sampling strategy was employed to recruit experts in Phase 1, while a convenience- and purposive sampling strategy was employed to recruit participants in Phase 2. Based on the guidance of Price et al. (2004), these sampling approaches were followed strictly and applied legitimately throughout the study to recruit participants in a way that aligned with the research design and was within the capabilities of the researcher and DCA. Furthermore, a total of 316 survey responses were collected when only 300 surveys were required. Given these considerations, the study's findings can be considered to have external validity, meaning they reliably represent the selected sample population. Thus, the results can be generalised to represent the whole sample population (Fink, 2003).

Since only adult Gauteng PT users who have used PT services in the last three years were included in the sample (as was decided in the sample inclusion- and exclusion criteria), the sample of 316 responses have both the necessary understanding and expertise to be part of the sample. As such, the study's findings can be considered accurate, but its reliability cannot be ascertained as it is described by the degree to which

the study's results can be replicated by any other researcher in another study by applying the same methodology as the original study, also providing an indication of the dependability of a sample participant's responses (Hones, 1990; Louangrath, 2015; Bernard, 2002; Alexiades, 1996).

Due to the 98.2% correlation determined between the presence of HCD measures in Gauteng PT and commuter satisfaction with and operational success of those services, the study's research hypothesis (shown below) can be **confirmed**:

The South African PT industry could be more operationally successful and desirable to commuters if it incorporates HCD principles into its fundamental planning and development.

Therefore, the expected results do not vary from the research findings observed. Therefore, according to literature, the study's findings can be considered valid.

5.5 Recommendations for further research

The findings from Questions 1 and 2 showed that many Gauteng PT users are captive to the MBT service for long- and medium-distance trips, even when they prefer a private vehicle or MaaS, because they cannot afford to pay more. Additionally, the findings from Question 7 showed that some Gauteng commuters are displeased by the inconvenient payment system, lack of safety and poor comfortability when using the taxi. Thus, it is recommended that further research is undertaken on how to optimise the MBT fare payment system by making it touchless and electronic. Nearly half (45.7%) of the sample supported the idea of paying for all their PT services using one smart card, instead of carrying cash, displaying an interest in more convenient fare payment.

Aligning with the MBT industry, many participants (13.6% of the sample) asked for better customer service when using Gauteng PT services, asking that taxi drivers respect their customers more, have a better customer focus and are more polite, one participant even stating that "taxi drivers need training with respect to customer service". Further research is thus recommended to investigate the possibility of training MBT (and even BRT) operators on offering better customer service to their passengers, as the findings of this study have shown that a commuter's willingness to pay for PT is directly related to their perception of that service, and that commuters will desire a service more if their concerns and suggestions are considered and acted upon.

Further research is recommended to investigate the impact of assigning clear, effective roles and functions to each travel mode. Since the correct type of survey data could not be collected to investigate its potential, it is recommended that further quantitative studies are conducted to investigate the impact of MBT and BRT services acting as feeder services to the rail service in Gauteng. Furthermore, good recommendations

and a framework for mode roles and functions in an integrated system is recommended, as this may offer great guidance for other parts of South Africa that plan to integrate their PT network.

Since the study did not go in-depth on the functionality, characteristics and capabilities of the integrated PT control centre proposed, further research is recommended on this matter to investigate the potential of this concept and how it can be practically developed in local municipalities in South Africa. In addition, the idea and development of an integrated PT application that allows transport authorities to remain in constant communication with their commuters, manage and communicate with all modes in the network and give commuters a platform to raise concerns (while being heard and acted upon) should also be further investigated, as Gauteng commuters supported the travel benefits thereof. How this application links to the control centre in real-time should also be investigated.

Also, since this research focused only on the Gauteng Province, similar research can be conducted in other provinces in South Africa to assess whether the findings hold true. This study's findings have shown great promise for more human-centric service delivery in Gauteng's PT, so there exists a chance it could benefit other provinces in South Africa too.

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Addendum A

Addendum B

A. TRANSPORT SERVICE USE $\longrightarrow$ ANSWER: MARK THE BOX WITH A ☒ CROSS

1	Which transport service do you use MOST OFTEN RIGHT NOW for each of the following trips?					
Long trip (from home to the city)		Walk/Cycle	Car	Train	Taxi	Bus
Medium trip (from home to visit a friend)		Walk/Cycle	Car	Train	Taxi	Bus
Short trip (from home to the shop)		Walk/Cycle	Car	Train	Taxi	Bus
2	Which transport service WOULD YOU PREFER OR WANT TO USE for each of the following trips?					
Long trip (from home to the city)		Walk/Cycle	Car	Train	Taxi	Bus
Medium trip (from home to visit a friend)		Walk/Cycle	Car	Train	Taxi	Bus
Short trip (from home to the shop)		Walk/Cycle	Car	Train	Taxi	Bus

B. PUBLIC TRANSPORT SERVICE USE & RATINGS $\longrightarrow$ ANSWER: MARK THE BOX WITH A ☒ CROSS

3	Which public transport service DO YOU USE MOST OFTEN?	Train	Taxi	Bus		
4	Rate how you feel about this public transport service	😠 Angry	😔 Disappointed	😐 Neutral	🙂 Pleased	😃 Very Happy
5	Rate your response to the statement: I enjoy using this public transport service	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
6	Rate your response to the statement: If this public transport service becomes more expensive, I will pay more to use it	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

C. PUBLIC TRANSPORT SERVICES ISSUES $\longrightarrow$ ANSWER: MARK THE BOX WITH A ☒ CROSS

7	South African public transport users have the following issues with public transport services. Which 4 issues make you MOST UNHAPPY with your public transport service?						
Difficult to access	Not reliable	Not always available	Poorly maintained	Long travel time	Too expensive	Payment system	Unsafe
8	Which changes to your public transport service would make your travel journey better?						
$\longrightarrow$ ANSWER WRITE:							

D. PUBLIC TRANSPORT SERVICE WAITING ROOM ⟶ ANSWER: MARK THE BOX WITH A ☒ CROSS

9	What would you like to see in the waiting area of a public transport service? Select any of these:							
	Free Wi-Fi	Security cameras	Local artwork	Disabled facilities	Comfortable seating	Bicycle parking	Vending machine	Travel information board
10	If you see the items you selected in a waiting room, would you pay more to use this public transport service?	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
11	Is there anything else you would like to see in the waiting area?							
	⟶ ANSWER WRITE:							

E. PUBLIC TRANSPORT SERVICE NEEDS & FEEDBACK

	Rate your response to the following statements ⟶ ANSWER: MARK THE BOX WITH A ☒ CROSS					
12	I would like the opportunity to give my ideas and create the transport service I use.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
13	I would be more interested in using public transport if my inputs were used to improve the service I use.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
14	Transport officials make an effort to understand what my biggest problems are and how they can help me.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
15	Transport officials will understand my needs better if they regularly use the same service I use.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
16	Some transport decisions are based on politics instead of what people might want.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
17	Poor public transport services negatively affect my lifestyle and my job.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
18	I would like to know if my public transport service will be late.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
19	If my public transport service is running very late, I would like to know which other service near me can take me where I want to go.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
20	When I am using a public transport service and it breaks down, I would	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	like to know where to report the problem.					
21	I would prefer paying for all my public transport using only one card, instead of carrying cash.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
22	Rate how you would feel if transport officials make a regular effort to understand your travel needs.	😡 Angry	😔 Disappointed	😐 Neutral	🙂 Pleased	😃 Very Happy
23	Rate how you would feel if transport officials involve you when creating a public transport service.	😡 Angry	😔 Disappointed	😐 Neutral	🙂 Pleased	😃 Very Happy
24	Rate how you would feel if you have access to every public transport service you want to use.	😡 Angry	😔 Disappointed	😐 Neutral	🙂 Pleased	😃 Very Happy

Addendum C

LOCATIONS FOR TAXI USERS

Maximum **197** responses required

Big field across from Virgin Active – many people wait there and taxis come by often

From Rosebank Mall outwards:

- Taxi Rank JR070 – Corner of Jellicoe Avenue and Cradock Avenue, Rosebank, Johannesburg
- Taxi Rank JR072 – Corner of M9 and Jameson Avenue, Melrose, Johannesburg
- Taxi Rank JR071 - 251 Oxford Rd, Illovo, Sandton
- Taxi Rank JR006 - West, Sandown, Sandton (just before Sandton Metro station)
- Taxi Rank – 11st Parkmore, Sandton (near Banchan Korean takeaway)

Joburg CBD:

- Taxi Rank JR168 – Corner of Angle Road and Staibs Street, New Doornfontein, Johannesburg
- Durban taxi rank - 52 Van Beek St, New Doornfontein, Johannesburg
- Enkomeni taxi rank - 20 Error St, New Doornfontein, Johannesburg
- Ellis park taxi rank – Corner of Error street and Staib street, New Doornfontein, Johannesburg

Hillbrow:

- Kempton park taxi rank - 19 Banket St, Hillbrow, Johannesburg
- Taxi rank JR063 – corner of Sophie de bruyn street and Claim street, Hillbrow
- Lesotho taxi rank - 78 Sophie de Bruyn St, Hillbrow, Johannesburg
- Ivory Park taxi rank - 25 Hancock St, Hillbrow, Johannesburg
- Park Central Taxi Terminus – corner of Plein street and Edith Cavell street, CBD, Johannesburg
- Taxi rank JR276 / MTN Noord taxi rank – corner of Plein street and Von Wielligh St, Johannesburg
- Zakariyya Park, Lehae Taxis - 62 Plein St, Johannesburg
- Taxi rank JR438 - 72b Kruis St, Johannesburg
- Taxi rank JR066 - 22 De Villiers St, Johannesburg

LOCATIONS FOR BUS USERS

Maximum **21** responses required

Parkhurst:

- Corner of 4th avenue and 17th street
- Corner of 10th street and 2nd avenue
- Corner of 1st avenue west and 10th street (parktown north)
- Corner of 7th avenue and 1st avenue west
- Corner of 6th street and 4th avenue
- Corner of 6th street and 7th street
- Corner of Victory Road and Greenfield road

Rosebank:

- Corner of 7th avenue and 2nd avenue
- Corner of Jan Smuts avenue and 8th avenue
- MANY around Rosebank Mall

LOCATIONS FOR TRAIN USERS (all Gautrain)

Maximum **24** responses required

Rosebank metro station - 130 Oxford Rd, Melrose, Johannesburg

Sandton metro station - 155 West St, Sandown, Sandton

Johannesburg Park station - A 41, Park Station, Rissik St, CBD, Johannesburg

Park station - 128 Leyds St, Johannesburg

Marlboro metro station - Linbro Park, Sandton

Addendum D

Time: 60 minutes

Interviewer: RB Carstens

Interviewee: [Public transport expert]

Study title: Investigating the impact of human-centric public transport design principles on the desirability and operational success of public transport in the Gauteng Province, South Africa – an exploratory, mixed-methods study.

Study aim: Offer a set of human-centric public transport design (HCPTD) principles that have been proven to work effectively in promoting elevated customer satisfaction and improved PT quality in South Africa. These principles provide a platform for public engagement and act as a mechanism for the voices of customers to be heard and incorporated into PT design.

Key:

- • : follow-up questions
- - : compounded follow-up questions

* : not of great importance, so can omit if need be or if not enough time is available or question already answered

Interview questions:

Question 1: From your experience, what role does a commuter play in the operational success of the South African PT system?

- • Does a commuter's cooperation and support affect the operational success of our transport system? How so?

Question 2: From your experience, what are the key needs of South African PT commuters?

- • Do you believe the fulfilment of these needs will result in a greater desire to use these services? How so?
- • *If these needs are not met, are there other reasons why a commuter would be dissatisfied with these services? If yes, please describe these reasons.
- • *Given how frustrated commuters are with unreliable PT services in South Africa, will commuters with satisfied needs be capable of constructively reforming our PT system? If yes, how come?

Question 3: From your professional experience, which of the needs mentioned above do you believe have not been successfully accounted for in South Africa?

- • What do believe can be done to address these unmet needs successfully?

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- Do you believe incorporating human-centred thinking into our PT design has the potential to provide for these unmet needs? Why?

<u>Question 4:</u> Which measures has your company put into place to accommodate the unique needs, preferences and behaviour of the people you design for?

- Do you believe these measures have been effective? How come?
- Do you believe additional measures are required to better accommodate for these human needs? If yes, please provide a general description of the measures you believe are necessary.
- *Do you believe using human-centred approaches would enable you to better accommodate for these needs? How so?

<u>Question 5:</u> From your professional experience, which aspects of South African PT design and services do you believe are currently the highest priority to address?

- Do you believe incorporating human-centred thinking into our PT design has the potential to enable these improvements? Why?

<u>Question 6:</u> Do you believe the incorporation of more human-centric thinking would be palatable for commuters and capable of meeting their travel needs?

- If *yes*, how so?
- If *no*, why not?

<u>Question 7:</u> How can South African *service design* evolve to incorporate more human-centric thinking? For example, the HCPTD principles offered by the study.

- How can South African *transport culture* evolve to incorporate more human-centric thinking?

*<u>Question 8:</u> From your understanding of the Integrated PT Plan for 2032, do you believe the proposed study could contribute to the integration of South Africa's PT network? How so?

<u>Question 9:</u> Do you have any more recommendations or insights to share that would benefit this study?

Addendum E

Time: 60 minutes

Interviewer: RB Carstens

Interviewee: [Human-centric design expert]

Study title: Investigating the impact of human-centric public transport design principles on the desirability and operation success of public transport in the Gauteng Province, South Africa -- a mixed-methods study.

Study aim: Offer a set of human-centric public transport design (HCPTD) principles that have been proven to work effectively in promoting elevated customer satisfaction and improved PT quality in South Africa. These principles provide a platform for public engagement and act as a mechanism for the voices of customers to be heard and incorporated into PT design.

Key:

- • : follow-up questions
- - : compounded follow-up questions

- * : not of great importance, so can omit if need be or if not enough time is available

Interview questions:

<u>Question 1</u>: Please briefly explain how your company employs HCD in its service provision.

- • Which human-centric measures have you found to be the most effective in your practise?

<u>Question 2</u>: When working with clients, which human needs have you found to be the most common?

- • Would providing for these needs satisfy customers and improve the demand for your service? (*Yes/No*)
  - - If **no***: Which *other* factors have you found are important when aiming to improve the demand for your service?
- • Which of these needs do you believe can be better accounted for, and how?

<u>Question 3</u>: From your professional experience, how is human-centric thinking currently being applied in South Africa? Please provide a few examples.

- • Have you noticed any gaps or issues in industry that can be addressed with HCD? (*Yes/No*)
  - - If **yes:** What are these gaps?
  - - If **yes**: How can HCD be utilised as a solution here?

<u>Question 4</u>: Do you believe older forms of design thinking in South Africa have fallen short in empathising with the needs of customers?

- If **no**: Please explain your view.
- If **yes**: Do you believe this paradigm of thinking is still beneficial to modern South Africa? (*Yes/No*)
- If **yes**: Why and in what way is it still beneficial?
- If **no**: How does this paradigm of thinking limit the potential of South African service provision?
- If **yes**: How do your clients respond to HCD versus this older form of design thinking?

Question 5: From your experience with South African PT, do you believe the design thinking behind PT service development is flawed and in need of positive reform? (*Yes/No*)

- If **no**: Please explain your view.
- If **yes**: Why and to what extent?
- If **yes**: What improvements do you recommend to bring about elevated customer satisfaction in South African transport services?

Question 6: According to your professional opinion, do you believe the use of more HCD in South Africa's service provision would resonate better with customers?

- If **no**: What would resonate better with South Africans customers?
- If **yes**: What are the benefits of incorporating more human-centric thinking into service provision?

Question 7: Based your experience with South African PT services, do you believe the incorporation of HCD into service provision would improve the demand for these services?

- If **no**: Please explain your view.
- If **yes**: What can be done to help PT service providers become more accustomed with HCD?
- If **yes**: How can HCD be used most beneficially by South African PT services?

Question 8: What do you believe are obstacles to getting human-centric elements embedded into South Africa's PT system?

- What do you recommend to overcome these obstacles, so that South African transport services can embody more human-centric values?

- What would spark a willingness to shift from older forms of designing thinking towards more human-centric transportation?

Question 9: Do you have any more recommendations or insights to share that would benefit this study?

Addendum F

Quantitative surveys

The first step to conducting survey research is defining what the objective of the survey is. Researchers should ask themselves what they want to achieve by handing out their surveys to their sample, what type of data they want to attain and what they plan to do with the results. Next, identify the type of quantitative survey questions (QSQs) to be used in the survey to obtain the desired data, based on the survey objective. QSQs can either be descriptive, comparative or relationship based. Firstly, *descriptive* questions assist a researcher in obtaining information about a variable so that it can be quantified, each specific question pertaining to a specific group of people. (Bhat, 2020).

Thirdly, a *relationship* question aims to establish any correlation, trend or cause-and-effect relationship among two or more variables, indicated by asking what relationship exists between dependent and independent variables in the study (Bhat, 2020). All questions posed in the survey should be defined based on the study's objectives and kept brief, basic and free from any ambiguity so that respondents have clarity what is needed from them. All questions should focus on obtaining in-depth information and understanding on the topics of focus. As a guide, start a survey with straightforward demographic questions and follow up with either closed-ended multiple choice questions (MCQs) or more qualitative open-ended questions. Just note that while MCQs can be processed simply, they have limitations to the degree of detail that can be obtained; open-ended questions offer more detailed and personal information, yet they are more challenging to analyse (Bhat, 2020; Aziakpono, 2020).

After deciding which questions are used in the survey, identify both the independent and dependent variables being tested as well as the target audience for data collection. Independent variables are altered to stimulate a change in the dependent variable, meaning they have a cause-and-effect relationship that is studied in the field within the scope of the research topic. Variables are either nominal, ordinal, interval and ratio type, assisting in more specifically defining the variable used. *Nominal* variables state only the name of the variable, *ordinal* variables include the name and order, *interval* the name, order and interval of the variable and *ratio* includes the latter plus a zero-value option (Bhat, 2020).

Next, as noted above, care must be taken to design and select the correct survey structure, ensuring that complementary questions are positioned alongside one another and the flow of the survey is effective to approach (Bhat, 2020). Related questions can be preceded by a disqualifier question, meaning if the answer is "no" to the first question, there is no need to answer the following one; this saves both the respondent and researcher time and effort (Albertyn, 2020). After optimising the layout of the survey to collect the necessary insights and information from respondents in the most efficient way, the researcher should then

evaluate how easy the questions are to read, clarifying any ambiguity and ensuring the target audience understands what information is needed from them. Once this step is finished, the survey is ready for data collection (Bhat, 2020).

Select the areas which would provide the most accurate data and collect data from the target groups defined, making sure that enough surveys are completed to achieve the study's aims – sampling for this study is discussed in the consequent section. Once completed, summarise and tabulate the answers into computer software and remain aware of any trends or patterns that arise. Process the data obtained using a selected statistical method and, once the statistics have emerged, interpret what the findings imply to the study of interest. A more in-depth discussion on data analysis and synthesis is provided in the data analysis section of this study (Almeida, Queirós & Faria, 2017).

Correlation research

At first, the researcher should choose the target audience that would offer data most aligned with the study's objectives and describe which variables are to be investigated in the research (Almeida, Queirós & Faria, 2017). Next, data is collected from the chosen sample and location via two main methods. *Naturalistic observation* studies the behaviour of the sample in their natural habitat, making sure people are unaware of the researcher so that their behaviour remains natural and thus most accurate. *Archival data* is also gathered from researchers who had carried out primary research of a similar nature, thus utilising information from the past to inform the insights and trends observed in their study (Fleetwood, 2020).

After a sufficient quantity of data is collected, the next stage of research is to quantify the correlation and covariation (i.e. the variation in correlation) between the variables of interest (Almeida, Queirós & Faria, 2017). This correlation is generally illustrated using a scatterplot diagram, which plots data points resulting from two variables on a two-dimensional *x-y* axis. If the two variables are related, the scatterplot can indicate either a *positive* relationship, where the increased value of one variable causes an increased value in the other, or a *negative* relationship, where the increased value of one variable causes a reduced value in the other (Price et al., 2017).

Through a sequential statistical analysis, a factor known as *r*, the Pearson Correlation Coefficient, results, describing quantitatively how strongly two variables are related (Cooper & Schindler, 2001; Almeida, Queirós & Faria, 2017). The value of r ranges from -1 (the strongest *negative* relationship illustrated as a *negative*-gradient straight line) to +1 (the strongest *positive* relationship illustrated as a *positive*-gradient straight line); *r* = 0 indicates there is no correlation between these variables, illustrated as a cloud of data points on the scatterplot diagram. The accuracy of *r* is impacted by the validity and reliability of the data

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collected, meaning the surveys distributed should be answered accurately and the data analysed correctly to yield a reliable description of correlation (Leedy & Ormrod, 2005).

Importantly, *r* does not accurately estimate the correlation between non-linear relationships and a special case called the "restriction of range". *Non-linear relationships* are illustrated by a curved or U-shaped line (either a trough or crest), thus embodying multiple values and signs for *r*. In the case of *restriction of range*, the range of either one or both of the variables in the study sample is restricted when compared to the greater population, for instance the age range of the sample being chosen narrower than the age range in the greater population to which it is relevant or applied. Scholars should attempt to design their research to steer clear of restriction of range, by thoroughly scanning their sample choice and data for any variable range restriction that would affect the viability of the results, using *r* as a reference to evaluate whether the variable correlation approach is well enough informed (Price et al., 2017).

Addendum G

QUALITATIVE INTERVIEWS							INSIGHT EXTRACTION	27 EMERGING THEMES (ETs)																		4 MAIN QUALITATIVE INTERVIEW THEMES WITH ASSOCIATED SUBTHEMES (STs) & ETs

Column 1 — QUALITATIVE INTERVIEWS:

PTE3
PTE2
PTE1
HCDE3
HCDE2
HCDE1

1 →

Column 2 — INSIGHT EXTRACTION:

213 HCD & PT DESIGN INSIGHTS

2 →

Column 3 — 27 EMERGING THEMES (ETs):

ET1	ET2
ET3	ET4
ET5	ET6
ET7	ET8
ET9	ET10
ET11	ET12
ET13	ET14
ET15	ET16
ET17	ET18
ET19	ET20
ET21	ET22
ET23	ET24
ET25	ET26
ET27	

3 →

Column 4 — 4 MAIN QUALITATIVE INTERVIEW THEMES WITH ASSOCIATED SUBTHEMES (STs) & ETs:

Theme 1: Emerging solutions to key PT problems
ST1 (ET26, ET14); ST2 (ET22, ET18, ET19); ST3 (ET11, ET12); ST4 (ET5, ET15, ET16)

Theme 2: Inadequate stakeholder consultation in transport service provision
ST5 (ET9, ET13); ST6 (ET21, ET2)

Theme 3: Transitioning from systems-centred to human-centred design
ST7 (ET17); ST8 (ET7); ST9 (ET4, ET24); ST10 (ET1, ET20, ET6)

Theme 4: MBT domination in South African PT
ST11 (ET3, ET8); ST12 (ET10)

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Addendum H