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The first/last mile experience of student's commuting between the Metrorail and Gautrain stations and the University of Pretoria's main campus in Hatfield.

By

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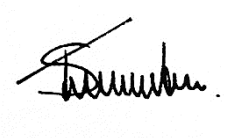
2.0 Declaration of originality

I declare that the mini dissertation, The first/last mile experience of student's commuting between the Metrorail and Gautrain stations and the University of Pretoria's main campus in Hatfield, which has been submitted in fulfilment of part of the requirements for the module DIT 801, at the University of Pretoria, is my own work and has not previously been submitted by me for any degree at the University of Pretoria or any other tertiary institution.

I declare that I obtained the applicable research ethics approval in order to conduct the research that has been described in this dissertation.

I declare that I have observed the ethical standards required in terms of the University of Pretoria's ethic code for researchers and have followed the policy guidelines for responsible research.

Signature: 

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5.0 Abstract

Various strategies have been implemented in South Africa to negate historical spatial injustices, such as the Gautrain and Metrorail train systems. These systems are envisioned to facilitate geographic desegregation and access to basic rights such as education. However, hard infrastructural systems generate forms of inequality that hinder the intended purpose of the system. There is currently a gap in literature on the experience of student's commuting to and from places of education in South Africa and the first/last mile of the daily journey. The study uses the grounded theory approach to achieve a thorough and layered understanding of quantitative and qualitative data of the study area, Hatfield. By using first/last mile spatial components and factors identified in literature, hard and soft infrastructural interactions are investigated along predominant first/last mile routes to discover factors that hinder or facilitate the journey. This is critical to study as commuting to places of education is the second most common reason people in the country commute. The study revealed that there is spatial dysfunction within the urban transportation system on various scales for student's commuting to and from the University of Pretoria. This included injustices with regard to train systems accessibility, efficiency, reliability, and affordability, unsafe spaces of movement, and a lack of connection to the urban environment along first/last miles. These spatial components and factors demonstrate nuances of inequality. However, it is also evident that there are spaces of hard and soft infrastructure that negate spatial exclusion and isolation which should be used as examples for future urban developments. These spaces are essential to identify and understand in a developing country emerging from past spatial injustices.

Keywords: "transport infrastructure," "commuting students," "first/last mile," "University of Pretoria," "Hatfield."

6.0 Definition of terms

Urban anchor: A sizable, permanent institution (such as hospitals or universities) that achieve social, physical and/or economic ties to its surrounding context and communities (Bank, Cloete & Schalkwyk, 2018). In this study, the University of Pretoria acts as an urban anchor as it draws in a high density of people to Hatfield.

Grounded theory approach: A method of inquiry that enables a researcher to study a particular experience and discover systems or theories that are established on the analysis of real-life data (Delve & Limpaecher, 2021). The theory development of this study formed during an iterative process of data collection and analysis of both quantitative and qualitative data.

Urban: An area that is built up and developed for human settlement and in turn has a high population and infrastructure density. The urban context referred to in this study is Hatfield.

Inequality: Imbalanced or unjust distribution of opportunities and/or resources among people in a given society or space. This incorporates overlapping themes on social, economic and spatial spheres (Koh, 2020), which are studied on a macro, meso and micro-scale in the project.

First/last mile: The section of a commuter's journey between the main public transport mode and journey origin/destination (Venter, Hayes & Watts, 2022). This excludes transfers between main mode portions. The study is limited to the use of non-motorized commuting along this section of the journey which includes walking, cycling and skateboarding. This section of a commuter's route is globally known as the 'last/first mile' and the term 'mile' in this phrase has no reference to a specific distance of the route. There is no local interpretation of the phrase and therefore the 'first/last mile' will be used in this study.

Hard infrastructure: The physically built environment. The hard infrastructural elements referred to in this study include railway lines and stations, buildings, roads and their respective sidewalks, fences/walls, gates and sidewalk elements such as bollards, paving and streetlights.

Soft infrastructure: The social, economic, legal and other arrangements around hard infrastructure components that facilitate infrastructure operations and functions (Devenish et al., 2022). This study will specifically focus on social arrangements and spatial qualities along the identified routes that form around commuting student's.

Informal vendor: An individual that is operating outside of the formal retail/trade system and are conducting business without protection or legal status (Giroux et al., 2021). In this study, informal vendors are individuals who arrange themselves and conduct business along movement routes. They are informal as the location of where they set up may change if paths of movement change.

Desktop data: Secondary data that is already existing such as data available on the internet from websites. This data is obtained through desk research from sitting at a computer.

7.0 Introduction and overview of theme: Urban Infrastructure and Inequality

The Sustainable Development Goal's (SDGs) 4, 8, 9 and 11 recognize a universal right to inclusive, sustainable, safe and resilient human settlements, urban environments and infrastructure that promote accessibility to economic opportunities and quality education (United Nations, 2023). However, developing countries and contexts that experience extreme inequality with regard to wealth inconsistency and access to infrastructure worsen the goal of making this universal right achievable. In South Africa, the complex past of Apartheid further impaired the aim of achieving this universal right due to a socially unjust history and emphasis on segregated development (Strydom, 2014).

The transformation of current urban contexts is critical to enable citizens, especially the vulnerable majority, to access livelihood opportunities (Simone, 2004). There is therefore a demand to establish innovative ways of responding to these complex urban environments of mobility and operation. For the SDGs to be achieved in South Africa, there needs to be a significant shift in the understanding of urban infrastructure and the re-evaluation of current approaches and systems in which people use and access it (Devenish et al., 2022). Research suggests that urban infrastructure is not a simple system of hard infrastructural devices but rather a network of soft infrastructural interfaces that connect or prohibit people from accessing services, resources and socio-economic opportunities. Therefore, urban infrastructure creates environments of inequality within urban contexts (Rubin, 2020). Through studying how people commute to and from socio-economic opportunities one can understand factors hindering or facilitating ease of access and equality to the prospect.

8.0 Background of identified topic

8.1 General issue: Access to education in South Africa

The largest movement of individuals that is unique to developing countries is inland migration to urban areas that hold opportunities and development prospects, such as places of education (Walker & Mathebula, 2019) In South Africa, the second most frequent purpose of commuting, with labour commuting as the most frequent, is the movement from geographically distant areas to places of education. This is from both rural and urban areas. Rural areas do however present significantly more challenges for student's commuting to education than those from other urban areas (Ballard et al., 2021; Walker & Mathebula, 2019) Along with the SDGs, the South African constitution also recognizes a universal right to basic services and sustainable cities (SAHRC, 2012). This includes the universal right to education. However, with the country's socially unjust history, this right is hindered and inequalities surrounding educational prospects has become a serious human development issue within the country (Strydom, 2017).

In times of Apartheid, universities were envisaged by the apartheid government as place-based tools of social and economic development for white people (Bank et al., 2018). The universities developed in the early 1900s, such as the University of Pretoria, were introduced into locations that were in closer proximity to white-zoned areas. This resultantly drove a system of isolated development of white communities. After the establishment of democracy in 1994, the role of universities changed to address the skills imbalance that had been skewed along racial and class lines. From this time onwards, universities were viewed as agents for regional development as they have the potential to uplift economic and social status (Bank et al., 2018).

However, today universities in the country are seen as icons of exclusivity with high-fenced boundaries that keep education and student's in and everybody else out (Bank et al., 2018). The internal emphasis on education in South African universities has often led to the failure of addressing urban issues directly beyond the boundary fences (Bank et al., 2018). Although this

physical isolation demonstrates exclusivity of education access, institutions of higher education bring together various groups of people to achieve common ambitions. Universities act as critical nodes of equalization of chances and democratization of society as they allow for equal opportunity for people (Bank et al., 2018). Access to tertiary education in South Africa is a key component in realizing economic safety and can eliminate the extreme wealth disparities and inequalities in the country (Walker & Mathebula, 2019) However, this may only be achieved if access to tertiary education is financially and spatially accessible.

The majority of South African youth are still excluded from higher education as only 18% of children that enter grade one in any given year participate in tertiary education (Strydom, 2017). Due to extreme geographic locations, most of South Africa's youth is educated at the educational facility in closest proximity to their place of residence. Therefore, the youth that are located in poorer isolated areas tend to receive poor resourced and poor-quality education (Strydom, 2017). Due to tertiary education being an agent for economic and social development it is sought after by the majority of the current youth. To participate in tertiary education not only generates individual economic benefits and development but also contributes to individual well-being. Despite the geographic and socioeconomic divisions, there is a number of youth who reach and participate in tertiary education to develop future prospects. By studying how people access tertiary educational institutions in the context of South Africa, one can understand factors hindering or facilitating equality to a place of socioeconomic development.

8.2 Urban issue: Commuting to higher education in South Africa

The University of Pretoria is described as one of South Africa's leading universities (Bank et al., 2018). This causes student's from all over the province to commute to the university, even if there are alternate tertiary education opportunities in closer proximity to where they reside. For others, the institution is the closest and most viable tertiary opportunity available to them. Regardless, the journey to participate in tertiary education is not always smooth, as the experience of commuting to a university campus is shaped by numerous uncontrollable factors. These factors include access (or lack of) to monetary resources (Ballard et al., 2021; Walker & Mathebula, 2019), transport infrastructure and geographic distance between place of residence and place of education.

This is iterated in the essay 'Late' in the book *Movement Johannesburg* (Silverman, 2015). The essay elaborates on the daily struggles of a student at the University of Witwatersrand, who resides at a distant geographic location and commutes daily to and from the university campus via public transport. To attend an 8am lecture on time, the student wakes up at 4am and takes multiple modes of public transport to reach the campus. However, along the journey there are unforeseen events such as transport delays, load shedding or cable theft which will make her late for this lecture. If the student oversleeps, she has to spend twice as much money to commute to campus via a different mode of public transport. The essay elaborates on the fact that the spatial dysfunction of the current urban system is the only certainty the student experiences along the daily commute. The essay elaborates on how these student experiences are extremely common in South African contexts. The commute to educational institutions amongst an urban system of spatial dysfunction includes multiple modes of commuting as more often than not, the main transport mode does not take a commuter to the final destination. This results in the 'first/last mile' of a commuter's journey.

8.3 The first/last mile of a commuter's journey

The 'first/last mile' refers to the section of a commuter's journey between the main public transport mode and the journey's origin/destination (Venter et al., 2022). For example, in the context of this study, the main public transport mode is the train systems (Metrorail and Gautrain) and the journey origin/destination is the University of Pretoria's main campus in Hatfield.

This section along a commuter's journey is interesting to study as the in-vehicle quality of motorized transport is paid more attention to by transport planners (Venter et al., 2022). The in-vehicle experience focuses on vehicle quality, speed and route of the vehicular section of the journey. As main public transport modes do not always directly reach the origin/destination of a commuter's journey, the first/last mile concept is established. This section of a commuter's journey is most commonly completed by means of walking, cycling or skateboarding. The experience and factors affecting this section of the commute obtains less consideration and research and is therefore, more often than not, of a poorer quality (Venter et al., 2022). The quality of the first/last mile plays a significant role in the overall satisfaction of the journey (Venter, 2020). This part of the journey is important to attain and attract commuters and may have implications on the effectiveness and equity of the various transport systems and routes (Venter, 2020). The environment of this part of the commuter's journey is also extremely diverse as it encompasses the interaction of a variety of role-players, conditions and forms.

It is important to study the first/last mile of commuting student's to gain an understanding of factors that facilitate or hinder the journey to the basic right of education. The study of commuting student's experiences can give light to hard and soft infrastructural inclusions or exclusions that a commuter may experience daily. A literature analysis in section 13.0 elaborates on the qualities and spatial components of the first/last mile that will be investigated in-depth.

This project aims to investigate the role that urban transportation, public spaces and pedestrian mobility infrastructure play in facilitating or hindering access to the basic right of education in the context of Hatfield, Tshwane. The Hatfield precinct is of particular interest as it is envisioned as an educational precinct around the University of Pretoria's main campus. The precinct is connected to the broader context of Tshwane through various transport systems and experiences a high influx of student's commuting to and from the area during university semesters.

8.4 Hard and soft urban infrastructure interactions

Transport infrastructure is often associated with physical components such as roads and railway lines (Rubin et al., 2020). However, through an extended lens, infrastructure can be examined to include systems, people, practices, and processes interacting to embed or negate inequalities in urban environments. Through this lens, one can understand relationships between social conditions and practices in urban environments that affect the quality of life and day-to-day experience of commuters. Therefore, the concept of soft infrastructure is formed. It refers to the social and economic arrangements around hard infrastructure components that facilitate infrastructure operations and functions (Devenish et al., 2022). This study will specifically focus on social arrangements and spatial qualities along the identified routes that form around student's commuting. Adequate transport infrastructure and means of mobility is a basic need that requires attention and analysis, in an attempt to consider living standards for achieving educational well-being (Walker & Mathebula, 2019) Therefore, understanding the journey and daily experiences of commuting students and their contexts can facilitate awareness of day-to-day realities, challenges and nuances (Walker & Mathebula, 2019; Venter et al., 2022). This can further facilitate developing sustainable transport infrastructure options and routes.

8.5 Relation and application to architects and urban designers

This study makes a primary investigation of the pedestrian movement corridors surrounding an anchor institution by mapping and observing the thresholds of arrival and exit for students who are moving on foot. The documentation and observations of hard and soft infrastructure interactions along first/last mile routes will focus on spatial relationships and features that may cause inclusion or exclusion. The awareness of these relationships will allow architects and urban designers to gain an understanding of how the current urban environment is impacting the experience of the people that use it daily. It will allow insight and guidance on future urban designs, spatial principles or strategies to positively enhance a commuter's journey experience and ideally negate past spatial injustices.

9.0 Problem statement

As it is important to assess measurable statistics and predetermined hard infrastructural systems, it is also important to assess the soft infrastructural systems and the environments that enable or hinder student's commute, wellbeing and experience (Strydom, 2014). It is therefore important to analyze the environment and social context that various student's make choices and commute in. This will bring to light daily spatial arrangements that counteract the development and vision of a more equitable and accessible commute to a place of education.

The Hatfield Metropolitan Node Precinct plan's (Habitat Architects et al., 2020) goals include the development of Hatfield as a cohesive educational environment that provides convenient, secure, inexpensive and reliable access between various land uses through public transport and non-motorized movement networks. The precinct plan outlines the challenges of Hatfield, which includes connectivity, permeability, isolated and fragmented land uses and the lack of proper streetscapes. The objectives of the precinct plan include incorporating the university campus into the surrounding context to improve accessibility and permeability of street edges. This is envisioned to create a pedestrian-friendly environment and connect public transport, public spaces and the university campus.

According to Rossetti et al., (2015), the university is highly accessible as there are various public transport stops within a 15-minute walking distance. However, the quality, experiences and interactions of these last/first miles from major transport modes to the university remain unknown. It is evident that there is currently a gap in knowledge on the spatial arrangements that hinder or facilitate the journeys of student's commuting to the university. This lack of understanding is present at a macro-scale in terms of student's commuting via the Metrorail and Gautrain systems from distant geographic locations; a meso-scale in terms of predominant first/last mile routes used in the Hatfield precinct and; a micro-scale in terms of the ground level experiences and spatial arrangements along first/last mile routes. It is, therefore, important to gain an understanding of the spatial components and conditions of the first/last mile of a student's journey to negate unjust experiences while commuting to places of education.

10.0 Research questions and objectives

In this paper, the aim is to review literature, desktop data and ground truth data relating to transport infrastructure and inequality with regard to student's commuting to the University of Pretoria. Specifically, the purpose of the paper is to:

i. Gain an understanding of the Metrorail and Gautrain railway systems;
ii. Gain an understanding of the student's first/last mile journey between the university's main campus and these two modes of public transport;
iii. Discover patterns of interactions between hard and soft infrastructures along predominant first/last mile routes;
iv. Identify spatial components along these routes that affect the journey experience and;
v. Discover nuances of inequality along these journeys to suggest possible solutions.

This project aims to investigate the role that urban transportation, public spaces and pedestrian mobility infrastructure facilitates or hinders access to the basic right of education in the context of Hatfield, Tshwane in South Africa.

11.0 Research framework

The theoretical context that the paper is situated in is defined within this section to frame the methodology used.

11.1 Research paradigm

Locating the study in a particular research paradigm demonstrates an understanding of the values, assumptions and beliefs that the research will uphold and be guided by (Kivunja & Kuyini, 2017: 27). These values, assumptions and beliefs are defined within the four sections that a research paradigm is comprised of. Namely, the epistemology, ontology, axiology and methodology. The research paradigm that this study is located in, interpretivism, is consulted with in relation to the study focus of commuting student's' experiences to guide the way the study is understood and interpreted.

11.1.1 Epistemology: Subjective

The interpretivist epistemology, concerning the urban study, emphasizes how the daily reality of commuting students can be understood and knowledge of these daily realities can be interpreted from the consideration and awareness of observations, experiences and occurrences (Sheffield University, 2023). As reality is subjective and can be considered differently by various individuals, the study will uncover knowledge by consulting both individual interviews and visual observations of how groups of individuals commute. The adoption of the interpretivist paradigm provides an in-depth understanding of the study context and leads to high-level validity of data as it is based on numerous individual contributions as well as general observations (Alharasheh & Pius, 2020: 42). This in-depth understanding creates an opportunity to uncover new knowledge of the subjective reality of commuting student's to contribute to the research discourse and therefore complements the grounded theory approach.

11.1.2 Ontology: Relativist

The relativist ontology perspective suggests that there is no single shared reality, as reality is subjective and multiple interpretations, experiences and understandings can be obtained from different individuals (Kivunja & Kuyini, 2017: 27). Reality can, however, be investigated and constructed by studying multiple perspectives and human interactions (Thomas, 2021). This viewpoint applies to the study methodology as it aims to understand commuting individuals' subjective interpretations and interactions with transport infrastructure. Consequently, revealing daily experiences and patterns of occupation along predominant movement routes. An emphasis on field research to understand these experiences, interpretations and patterns of occurrences is placed as it precedes theoretical investigation (Kivunja & Kuyini, 2017: 33), and the nature of reality of an individual is dependent on their context (Grix, 2002). Therefore, the interpretivist ontology is consistent with the grounded theory approach as it emphasizes a layered, in-depth analysis and collection process of subjective and objective data.

11.1.3 Axiology: Balanced

Axiology describes the approach to ethical considerations, values and decision making while performing the research (Merriam-Webster, 2023). Due to the subjective component of interpretivism, balanced axiology allows for research that is a holistic and unbiased representation of findings that also reflects the researcher's values (Kivunja & Kuyini, 2017). The use of multiple individuals' experiences analyzed through interviews is, therefore, a critical component in the study to gain a holistic understanding of the context and limit researcher bias.

The values, assumptions and beliefs described in the interpretivist research paradigms epistemology, ontology and axiology upheld and guided the methodology of the grounded theory approach in section 12.0.

12.0 Methodology: Grounded theory approach

The study analyzes hard and soft infrastructure interactions of students commuting via the Gautrain and Metrorail train stations and the University of Pretoria's main campus. This paper aims to gain an understanding of the predominant first/last mile routes and the interactions between commuters and the context along these routes. To investigate this topic, a grounded theory approach was consulted.

12.1 Literature review: methodology

The grounded theory approach is a research methodology that aims to develop theories that are grounded in systematically collected and analyzed data (Allen & Davey, 2018). The approach is used to understand social complexity in the urban fabric by iterating and layering data collected and critically analysing it at intervals while conducting field research. In the context of this study, a grounded theory approach is a useful method for an in-depth analysis of identifying socio-spatial patterns of hard and soft infrastructure interactions (Devenish et al., 2022). In the book *Cities and Forms: On Sustainable Urbanism* (2011), Salat et al., discusses how to understand and assess complex urban forms and arrangements through identified indicators and metrics. The metrics that were focused on to collect data along the identified first/last mile routes were namely land use, mobility and economy. These metrics were used as they emphasized factors that would affect a commuting student's journey experience. In the literature review on the first/last mile in section 13.0, specific urban components will be identified to evaluate the first/last mile in more detail.

12.2 Study area and context

The study area is analysed through a grounded theory approach on a macro, meso and micro scale and focuses on the predominant first/last miles between the Metrorail and Gautrain stations and the University of Pretoria's main campus in Hatfield, Tshwane. On a micro-scale, the study is limited to the direct path of movement and its immediate surrounding context which includes the immediate sidewalk conditions, fences, adjacent buildings or land uses, trees and any other direct interactions or arrangements. Building onto the first/last mile research done by Venter et al., (2022), the study will include information up to the main mode of transport used, including waiting areas, information access and cost, and up to the identified pedestrian gate of the university campus. On a meso-scale, the context of Hatfield is of particular interest as the area is envisioned as an educational precinct and has high densities of student's commuting through the area to get to the university's campus. The study also investigates how the train systems connect Hatfield to the broader context of Gauteng on a macro-scale.

12.3 Research strategy

To gain a layered understanding the study first consulted available desktop data for a broad understanding of hard infrastructural networks on a macro-scale within Tshwane. The urban infrastructure research group used public transport systems (Metrorail and taxi systems) and commuted out of and back into Hatfield to experience and observe firsthand how public transport systems operate. While consulting the desktop data, experiencing public transport networks and observing transport infrastructure on a meso-scale in Hatfield, literature was reviewed on the methodology and topic of interest (student's commuting to the university via the Metrorail and Gautrain systems).

Due to the lack of qualitative desktop data available on student's commuting to the university campus via the Gautrain and Metrorail systems, on-site observations, online surveys and interviews were conducted on a micro-scale. Participants needed to be interviewed in the study to gain an understanding of their perceptions and experiences of the first/last mile commuting routes. This gave insight as to why certain first/last mile routes were preferred over others. The qualitative and quantitative data on various scales was collected, analyzed and compared to existing data. This process (Appendix 11) was iterated to form an urban sample of the study area. Figure 1 demonstrates the papers overarching research strategy of how the urban form is analysed through a socio-spatial study of hard and soft infrastructure interactions through a grounded theory approach.

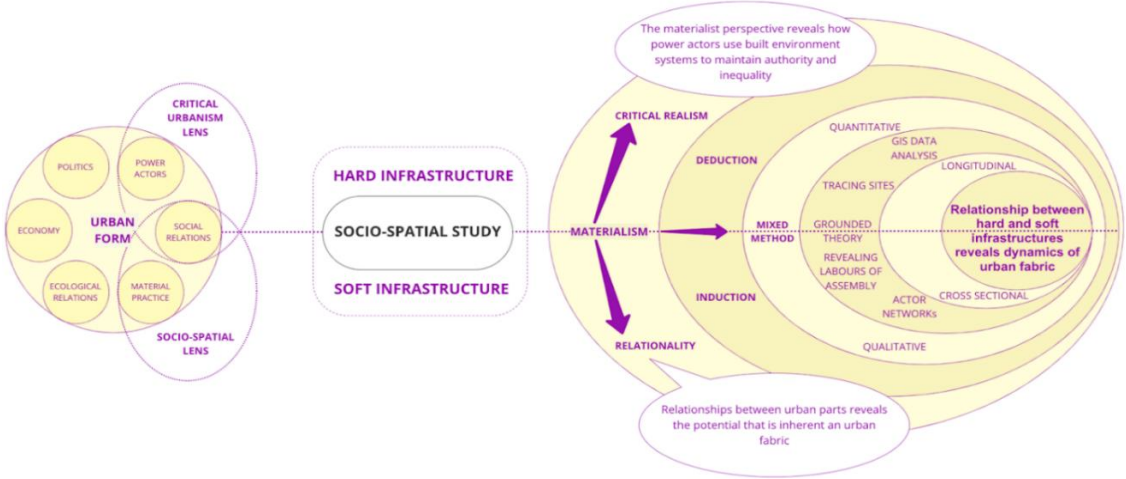

Figure 1: Research strategy for the study of urban infrastructure that informed the research methodology (Boano, Lamarca and Wade, 2017).

12.4 Research methodology

The grounded theory research method entails quantitative and qualitative data collection and analysis to build a theory that explains underlying patterns and themes in a chosen context (Scott, 2009). Through data layering and analysis during field research, the development of theories form through emerging patterns and relationships discovered. This method required an iterative approach (demonstrated in Figure 2 and 3) of data collection, analysis and conclusions on what has been discovered so far, what areas still need to be investigated and what data needs to be further collected (Appendix 11). This process created a thorough and layered depiction of urban arrangements, uses and experiences present along the identified commuting routes. Figures 2 and 3 describe how the grounded theory approach was utilized in the study.

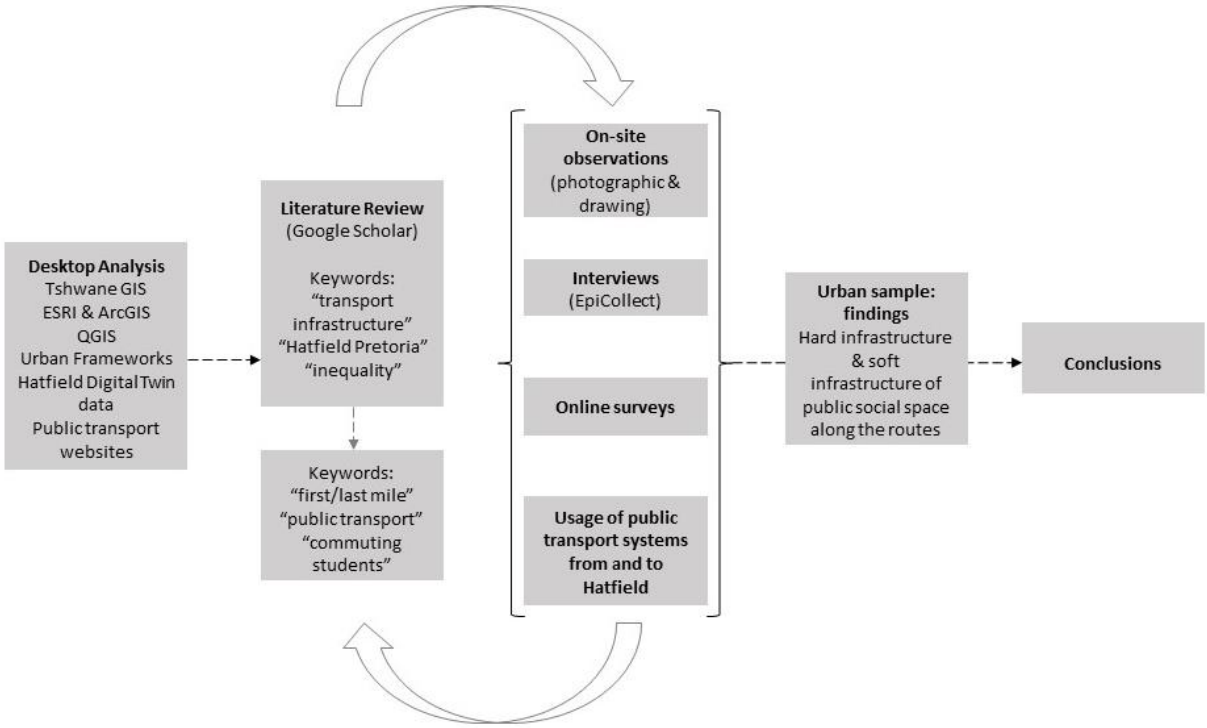

Figure 2: Research methodology of paper (Author, 2023).

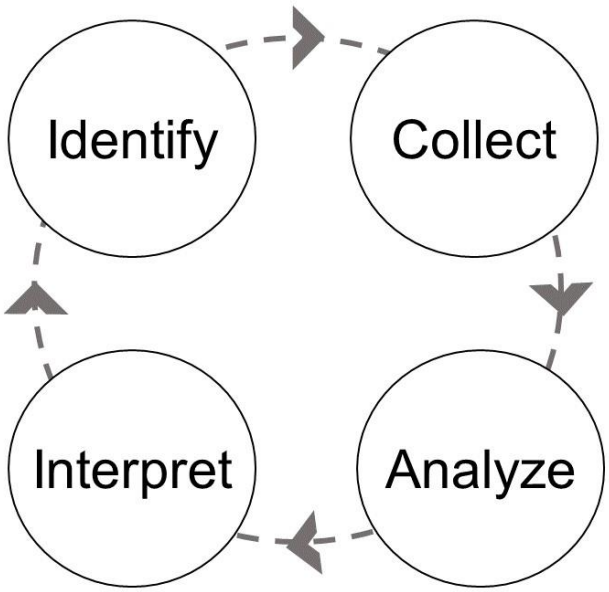

Figure 3: The iterative approach to data collection, analysis and conclusions that informed the urban sample in section 14.0(Author, 2023).

12.5 Sample universe

The desktop analysis included relevant data that was extracted from the following desktop platforms: Tshwane GIS, ESRI, ArcGIS, QGIS, urban frameworks, Hatfield Digital Twin City data and public transport websites. These platforms were chosen as they were the most accessible and readily available platforms of data presented. The data relevant to the study topic of Hatfield transportation infrastructure was saved on the research group's Google Drive platform.

The literature review was performed on Google Scholar and consisted of peer-reviewed articles only. The respective keywords demonstrated in Figure 2 were used to delimit the number of papers to 15 which were thoroughly reviewed and formed the literature review in section 13.0.

The online survey was distributed to EBIT (Engineering, Built Environment and Information Technology) WhatsApp groups due to their accessibility, and student's that used public transport answered the survey voluntarily in their own time.

The scope of the samples was limited to student's from the University of Pretoria that use the Metrorail or Gautrain train systems to commute to and from the campus daily. Student's commuting along the identified first/last mile routes were interviewed. The total number of student's interviewed was 19. However, a much larger number of students were visually observed along the movement routes. The interviewees were approached along movement routes and after the study was explained to them, they were asked to participate in the interview. In the study explanation, ethical considerations were explained in terms of identity and information protection. If the interviewee agreed to participate in the study, they were asked to sign an indemnity form. The questions were then asked and recorded. The last data collection process included the interviewees drawing which route they predominantly commute along which was done on A4 printed maps.

The social media platform, Facebook (Appendix 5), was also consulted as it is evident that many Metrorail commuters communicated with Metrorail management personnel on Facebook groups daily. The posts from the last 3 years were scanned through.

12.6 Research methods/instruments

The research methods used allowed for good quality and accurate data collection. The layered approach ensured the data is reliable and relevant to make accurate conclusions. The methods used included qualitative and quantitative research which also reduced any possible biases.

The quantitative research methods included a desktop study of existing data on any accessible data platforms and consisted of maps, train line information and urban frameworks. The desktop analysis required sifting through the above-mentioned databases and saving data relating to the study field. After an analysis of the quantitative data, it was evident that there is a gap in qualitative data and understandings recorded. This prompted the qualitative research methods which included interviews, observations, drawing on maps and online surveys. Interview questions were made on the geolocation software, EpiCollect, and answers were taken on a mobile application and uploaded to the online platform when completed. The online surveys were made on Survey Monkey and the link to the survey was sent on WhatsApp groups where students could answer voluntarily on their mobile devices. Interviewees that were asked to indicate the first/last mile they predominantly commute along, drew the route on an A4 printed map of Hatfield. On-site observations were recorded through photographs taken on cellular devices.

12.7 Data collection

To achieve the grounded theory approach, a layered data collection method was followed. The quantitative data collected allowed for an objective interpretation of the study, while the qualitative data collected allowed for a subjective interpretation and understanding. This data was overlayed and analyzed in conjunction with each other. The data collected was also a combination of primary and secondary data. The primary data collected consisted of interviews, online surveys, on-site observations and experiencing the transport systems. Whereas the secondary data collected consisted of online data from websites and GIS platforms. The primary data was collected through four on-site visits which were performed during peak hour times (5am to 8am, and 3pm to 5pm) to gain the full potential of the study. These peak hour commuting times were concluded from the online survey answers (Appendix 10).

The process of collecting and analysing data was iterative. This process was completed in 4 stages (demonstrated in Appendix 11). The first stage included desktop data, on-site visual observations and photographic data collection. The second stage included experiencing the public transport, interviews, visual and photographic observations and more desktop data collection. The third stage entailed visual and photographic observations and data collected through online surveys. The final stage included interviews, drawing on A4 maps and visual observations. All data collected was stored on the research team's Google Drive, where the information was accessible to the entire urban infrastructure research group.

12.8 Data analysis

The data analysis process followed the iterative approach demonstrated in Figure 3. From the desktop data analysis in stage one, it was clear that the maps available were objective, of a macro and meso-scale and no ground-truthing of the data was evident. Therefore, the first analysis of data informed the second stage as subjective data was needed on a ground level, micro-scale. Refer to Appendix 11.

The first stage of data collected on ground level entailed general visual and photographic observations of transport infrastructure in Hatfield. The analysis of this data indicated an interest and inquiry at the Metrorail and Gautrain stations as a large number of student's commute to and from the university via the train systems.

The second stage consisted of data collection at the train stations. The interviews, online surveys and visual observations suggested that specific movement routes were being used by students to get to and from the university. The interpretation of this data provoked the interest and data collection of the first/last mile routes from the Gautrain and Metrorail stations to the university campus.

The third stage entailed the data collection along the first/last mile routes between the Metrorail stations and the university campus. This data was analyzed through the first/last mile table in Figure 4. The analysis of hard infrastructure forms and urban fabric included the physical built environment such as roads, railways, fences/boundaries, lighting, signage and materials/textures, and the soft infrastructural components include how people inhabit the physical form, safety, comfort, relationships, experiences, reliability, efficiency and affordability was achieved. It was evident that more data was needed on the first/last mile routes between the Gautrain and the university campus as multiple first/last mile routes are possible due to the further distance of the station.

Therefore, the fourth stage of data collection included observing the predominant first/last mile route between the Gautrain station and the university campus. As the Gautrain station is located further away from the campus, multiple first/last mile route options are available. Therefore, in the interviews with student's commuting to and from the Gautrain station, the interviewees were asked

to indicate on a map the predominant route they use and questions about why they took that specific route were then asked. These maps were analyzed in terms of which route was predominantly used and why. The data was then analyzed in terms of the first/last mile table in Figure 4, and previously mentioned hard and soft infrastructural arrangements and forms. To conclude the data analysis process, all data collected was reviewed and analyzed as a whole to inform the urban sample in section 14.0.

12.9 Ethical considerations

To form an urban sample using the grounded theory method, qualitative data in the form of interviews and online surveys was needed to gain an understanding of individual commuting student's subjective experiences of the route. The method followed for collecting this data (explained in section 12.5) allowed for a method of recording knowledge without compromising personal information.

For ethical considerations, every participant was over the age of 18. Each participant was explained the outline of the research project before questioning, and each individual voluntarily participated in answering the interview questions or online surveys. The interviewee's identities are protected as no personnel information such as names or student numbers were asked. Each interviewee also signed an indemnity agreement form before answering any questions to state that they understood what the study was about and agreed to participate.

12.10 Limitations, delineations and assumptions of the study

The study is limited to student's currently studying at the University of Pretoria who use the Metrorail and Gautrain systems as their main mode of transport to commute to and from the universities main campus in Hatfield and their place of residence. Data collection and observations needed to occur during the university term as the number of student's commuting to the university during a holiday is unlikely. The study will not include the first/last section of the commuter's journey from their place of residence to the main mode of transport as it is not viable to observe onsite observations of various geographic locations. This section of the student's journey presents an area of possible future research. The focus on train networks and delimitation of other public transport networks like buses and taxi's is due to the train systems being the most common mode of public transport used to commute to educational institutions in the country (Walker & Mathebula, 2019), and the less frequent train stops allowed a more thorough investigation of existing student movement corridors. The less frequent train stops allowed for the observation of larger groups of student's exiting and entering the train stations at different times of the day. The interview answers (Appendix 10) also indicated that the train systems were the predominant main mode of public transport used by students.

13.0 Literature Review: Evaluating the first/last mile of a commuter's journey

Global transport-related issues such as traffic congestion, equal access to opportunities and healthier commuting environments has caused a focus shift in global transportation research over the past two decades to approaches that mitigate these issues (Lesh, 2013; Labuschagne & Ribbens, 2014). This international research shift investigates more sustainable and inclusive transportation concepts such as city walkability indicators, traffic calming and the first/last mile. These concepts are all focused around commuters' experiences and context-specific solutions. To achieve these context specific solutions and sustainable transportation infrastructure networks, one needs to investigate and understand adaptive systems, emergent patterns of use, as well as

networks and interfaces along existing movement routes (Bhan, 2019; Rubin et al., 2020). This understanding is achieved through studying hard and soft infrastructures that influence and affect urban movement on various scales.

Building onto this literature, this study looks at understanding and assessing current urban transportation infrastructure systems to access education in a South African city and how it is influenced by past social injustices, inequality and existing public transport networks. This is to further enhance use and operations, and aim to create public transportation environments that are sustainable, accessible and inclusive. The first/last mile is an adaptive system that demonstrates emergent patterns of urban transportation infrastructure use to get to a final destination from a main mode of public transport. This study aims to understand hard and soft infrastructural interactions along commuting students journeys, with an emphasis on the first/last mile section, to identify nuances of inequality within the local context of Hatfield.

The first/last mile refers to the section of a commuter's journey between the main mode of transport and the journey origin/destination (Venter, 2020). This concept is established as main public transport modes do not always directly reach the origin/destination of a commuter's journey and therefore a commuter needs to travel via a different mode of movement to reach the destination. This section of a commuter's journey is most commonly done by walking, cycling, skateboarding or a feeder mode of transport such as a bus. The experience and factors affecting this section of the commute usually obtains less consideration and research and is therefore, of a poorer quality (Venter et al., 2022). Globally, people commuting generally value the out-of-vehicle experience 2 to 3 times higher than the in-vehicle sections of the journey. However, the in-vehicle quality of motorized transport is paid more attention to by transport planners (Venter et al., 2022). The in-vehicle experience focuses on vehicle quality, speed and route of the vehicular commute. Whereas the out-of-vehicle experience includes waiting, walking and transferring on and off of the main mode of transport. This part of the journey can also attract commuters to a certain mode of transport or route taken (Venter, 2020). Therefore, understanding and evaluating the out-of-vehicle experience and first/last miles is critical to creating sustainable public commuting options.

Numerous international studies (Lesh, 2013; Park et al., 2021; Coffel et al., 2012), have used the first/last mile concept to gain an understanding on the lack of public transport usage to dispersed land uses and the influence infrastructure has on commuters experiences. Studies concluded that when the out-of-vehicle or first/last mile experience was poor, people opted not to use public transport altogether and used private vehicles. However, in developing countries such as South Africa, many people do not have the choice and solely rely on public transport to commute to dispersed land uses. These commuters are therefore constrained to use first/last mile routes no matter the condition. These international seminal works have influenced more recent studies completed in South Africa in terms of factors that determine the quality of first/last mile routes. The majority of these studies focused on a subjective data collection process that consisted of interviews and online surveys on the identified spatial components along the routes. This project will however also objectively observe individuals and the spatial components that make up the hard and soft infrastructure along the routes. This will follow the grounded theory approach and create a multifaceted understanding of the routes' hard and soft infrastructural interactions that hinder or facilitate the commuters' experience.

Recent papers investigate methods of assessing the quality of the first/last mile from the perspective of the commuter to gain an understanding of the experience (Venter, 2020). These methods of assessment build onto earlier studies on the walkability of an environment such as the walkability index developed by Frank et al., (2010) which considered aspects such as sidewalk quality and terrain. Methods that assess the first/last mile of a commuters journey build onto walkability literature by including the main mode of vehicular transport as well. This includes waiting areas, access to information and the cost of the main mode of public transport. Venter et al., (2022: 3) identified 7 themes to assess the quality of the first/last mile (Figure 4). These are namely comfort of

waiting areas, safety, information access, sidewalk quality/comfort, safety from traffic, cost and time/distance. For this study, the theme of 'land uses' was also included to assess land use types along the identified route and to gain an understanding of socio-economic interactions between the student's and the urban environment. Land use diversity and interactions with commuters affect the quality of the route as it impacts factors such as passive surveillance, access to goods and flow/concentration of people (Salat et al., 2011).

In South Africa, there is a significant gap in knowledge of first/last mile research. However, Venter et al., (2022) used the above-mentioned themes to broadly assess first/last mile routes of public transport users in the Johannesburg and Pretoria central business district areas. This study investigated a general assessment of the importance of the above-mentioned themes along first/last mile routes from multiple public transport modes (buses, taxi's and railways). The study concluded that safety was the most important factor to commuters along the routes, the cost of the main transport mode was the second most important and the comfort of waiting areas was the third most important factor. The study was very general and lacked insight into specific commuter types and interactions commuters had with spatial components within the identified themes in their daily environments.

The environment of this section of a commuter's journey is diverse as it encompasses the interaction of a variety of role-players, conditions and forms (Venter, 2020). It is therefore critical to investigate the first/last mile of commuter's journeys, to gain a holistic understanding of factors along the route that hinder or facilitate a commuter's daily experience. To assess the quality and experience along the first/last mile routes identified in Figure 10, the table below (Figure 4) will be used to guide the analysis of desktop data, observations and interview questions. The themes, specific features and spatial components described in Figure 4 were identified in various studies mentioned previously as vital to a positive and inclusive experience along the first/last mile.

Themes identified:	Features and spatial components to observe within themes:	Key references that justify the importance of first/last mile themes/spatial components:
Comfort of waiting areas	- Resting facilities - Shelter from elements - Economic opportunities (food/drinks)	Coffel et al. (2012)
Safety	- Safety personnel/police - Lighting of waiting and commuting areas - CCTV monitoring	Kim et al. (2007)
Information access	- Information on alternative routes - Train delays/arrivals	Coffel et al. (2012)
Sidewalk quality/comfort	- Walkway width and obstructions - Flat and even surfaces - Cleanliness	Park et al. (2014)
Safety from traffic	- Road crossings - Protected sidewalks/waiting areas	Fillone and Mateo-Babiano (2018)
Costs	- Main transport mode - Pay point machines - Pick up/drop off points	Fillone and Mateo-Babiano (2018)
Distance/time	- Walking distance to/from transport mode and university - Feeder bus frequency/waiting time	Van Soest et al. (2020)
Land Use	- Relationship between route and adjacent land uses - Connections/barriers - Informal vendors/activities	Salat et al. (2011)

Figure 4: A table of features and spatial components used to evaluate the quality and experience of first/last mile routes according to identified themes in first/last mile local and international literature (adapted from Venter et al., (2022)).

From Figure 4, the comfort of waiting areas refers to resting facilities, shelter, and economic opportunities along the route to purchase food or drinks (Coffel et al., 2012). Safety is an important factor and the presence of safety personnel, CCTV (Closed Circuit Television) monitoring and sufficient light will attract more commuters to use the route as it creates a sense of security (Kim et al., 2007). Access to information on alternative routes that can be taken between the destinations and train delays/arrivals creates an efficient and helpful environment to commute (Coffel et al., 2012). The quality of the sidewalks play a big role in the comfort of pedestrian movement as uneven surfaces, walkway obstructions and litter create environments that are difficult to navigate and move along (Park et al., 2014). Safety from traffic is a concern along any pedestrian route and therefore protected sidewalks and road crossings are critical factors (Fillone & Mateo-Babiano, 2018). The costs of the main modes of transport used are investigated and compared. The distance and time that it takes between the main mode of transport and university campus pedestrian gate's is analyzed. The Gautrain feeder bus system is acknowledged but not studied in great depth as it is an in-vehicle commute. Lastly, the additional theme recommended by Salat et al. (2011), land use, is analyzed in terms of passive surveillance, access to goods and flow/concentration of commuters.

By investigating these themes, features and spatial components through a subjective and objective data collection approach, a holistic understanding of the identified first/last miles is achieved. This revealed hard and soft infrastructural interactions and spatial components that hinder or facilitate the commute to and from a place of education via the train systems. This resultantly revealed scenarios in the urban environment that need improvement to create sustainable, accessible and equitable everyday commuting experiences. Due to the gap in knowledge of the out-of-vehicle and first/last mile experience of student's commuting to the university's main campus through the Hatfield precinct, an area of immediate study was made evident as Hatfield is envisioned as a student precinct.

14.0 Results and findings: Urban sample

The urban sample is a visual representation of the results and findings from the data collected on a macro, meso and micro-scale. This data includes and refers to the interviews, online surveys, literature review, visual and photographic observations and desktop analysis of maps, frameworks and transport websites (refer to appendices 5, 6, 8, 9, 10 and 11, Figures 5 to 26). On a macro-scale, data suggests that the university acts as an urban anchor and the train systems connect the larger context of Gauteng to Hatfield. On a meso-scale, the data collected indicates predominant first/last mile routes are evident between the identified train stations and the University of Pretoria's main campus. On a micro-scale, the literature review and data collected illustrate how the identified first/last mile routes between the stations and the university entrances demonstrate spatial components that hinder/facilitate the commuting experience.

14.1 Macro-scale: The University of Pretoria as an urban anchor

According to the Hatfield Metropolitan Node Precent Plan (Habitat Architects et al., 2020), the University of Pretoria's main campus acts as a predominant urban anchor in the Hatfield precinct as a large number of student's commute to the precinct during weekdays of university semesters (Figure 5).

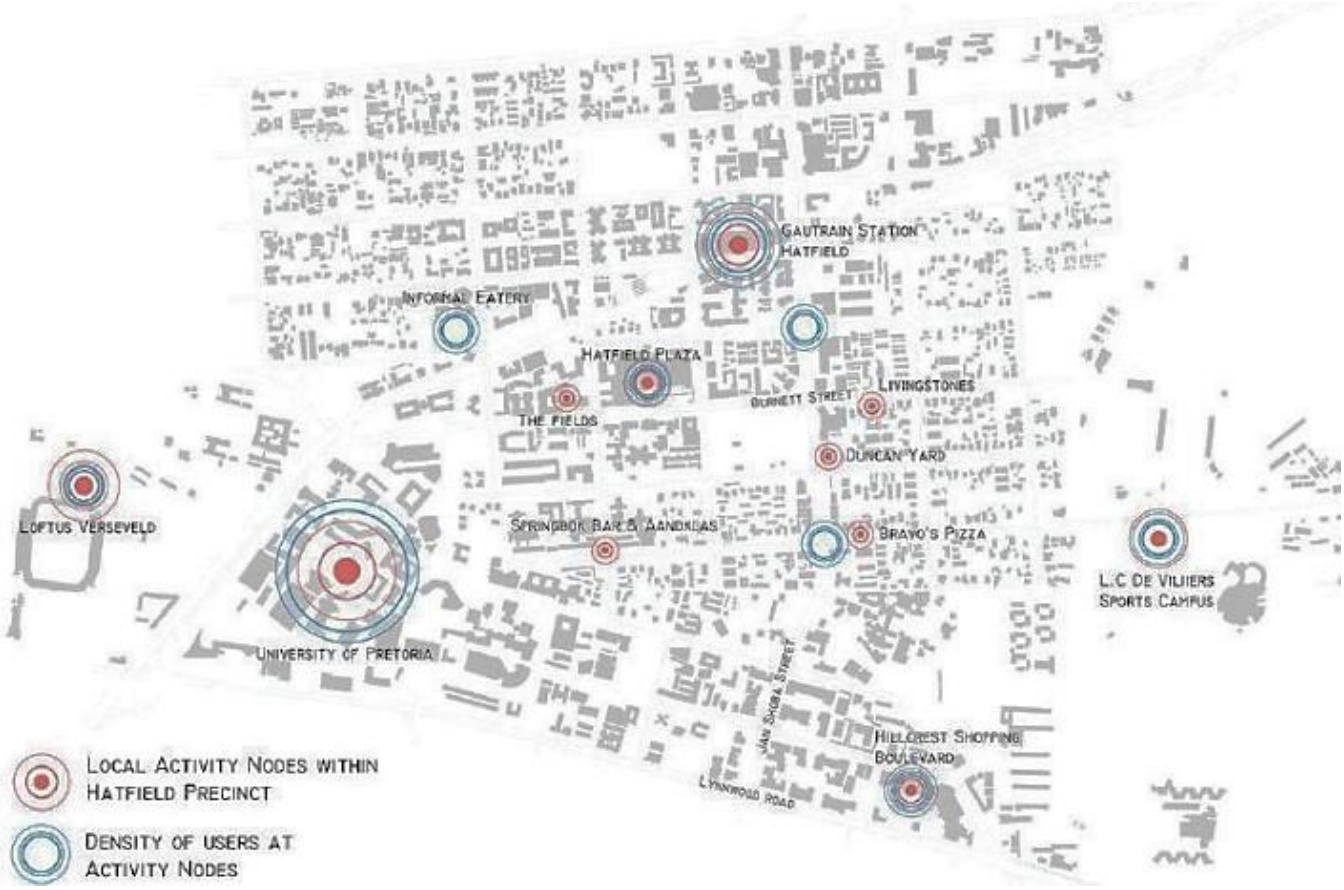

Figure 5: A Concentration of Activity map from the Hatfield Metropolitan Node Precinct Plan, illustrating the significant density of people per square kilometer at the University of Pretoria's main campus in relation to surrounding local activity nodes (Habitat Architects et al., 2020).

The University of Pretoria is currently following an anchor strategy for the redevelopment of the Hatfield precinct, in which the university is integrating into its surrounding urban context (Bank, 2022). To reimagine the surrounding context, the university is working with public and private partners to improve the spatial experience. This is demonstrated at the Moja Gabedi site in Hatfield where the University of Pretoria's unit for community engagement transformed a dumpsite into an urban garden and therapy site for the public (University of Pretoria, 2021). The re-imagination of universities as anchor institutions and the reshaping of their surrounding contexts in the country emphasizes urban sustainability (Bank, 2022). The university has embraced a strategy to eliminate barriers between education and people, and among racial and class groups (University of Pretoria, 2021). A division of this strategy is the engagement with external components of the campus, such as public transport infrastructure, to foster inclusivity and establish equitable access. The university is implementing the Hatfield Spatial Development Framework (2011) which emphasizes social transformation and urban renewal to connect the university campus physically with its surrounding urban context and systems.

The opportunities of university edges are demonstrated in Syracuse University in New York (Figure 6), where the semi-public university is rethinking campus design to be incorporated into urban life (Baldwin, 2023). The campus edges extend into the surrounding urban context through public walkways, social and landscaped spaces for both student's and non-student's to use. The public pedestrian spaces connect various university and urban activities and programs and instead of fences that border campus peripheries, building facades act as barriers. This precedent demonstrates the integration of a university campus and the surrounding urban transport infrastructure.

Figure 6: University campus peripheries that contribute to the surrounding public urban context through public social/resting spaces, removing boundary fences and integrating public movement routes (Baldwin, 2023).

The current main mode of transport to the university is private vehicles (Bank et al., 2018). However, many student's use public transport as it is their only means of accessing the university, it is more affordable than using a private vehicle, and convenient in terms of avoiding traffic and accessing shops along the route. As train systems are the most common mode of public transport used to commute to educational institutions in the country (Walker & Mathebula, 2019) (Appendix 10), it is important to study and gain an understanding of student experiences along these journeys.

Student's reach this urban anchor through the Metrorail and Gautrain networks which reach distant geographic locations in the Gauteng region (Figure 7). Although both public train networks have the same goal of connecting people of geographic distance to areas of opportunity, the networks have various differences and commonalities that attract different students to take one or the other network. As seen in Figure 7, the Metrorail network reaches a greater number of geographic locations at more frequent geographic intervals than the Gautrain network. These locations include poorer areas such as Sausville and Mabopane. Whereas the Gautrain system currently has fewer stops. However, these stops are in significantly wealthier areas with major economic development such as Sandton. The Metrorail network is significantly lower priced than the Gautrain (as seen in figure 8), as the Metrorail is approximately R1.50 per kilometre travelled and the Gautrain is approximately R6.50 per kilometre travelled. The high cost of the Gautrain is seen as a systematic exclusion of low-income earners (Ndwandwe & Gumbo, 2018) and attracts people of a higher income (Venter, 2020). As seen in Figure 9, the Gautrain stops at stations more frequently and therefore users experience a shorter waiting period. The train stops every 10 minutes during peak times and every 20 minutes during off-peak times. Whereas the Metrorail train stops are less frequent and therefore users wait for longer periods of time. The train stops at Metrorail stations every 45 minutes during peak times and 90 to 120 minutes during off-peak times. As demonstrated in the figures below, there are significant differences in the two train systems in terms of cost, reliability, and geographic location of stations and therefore each system attracts different groups of students.

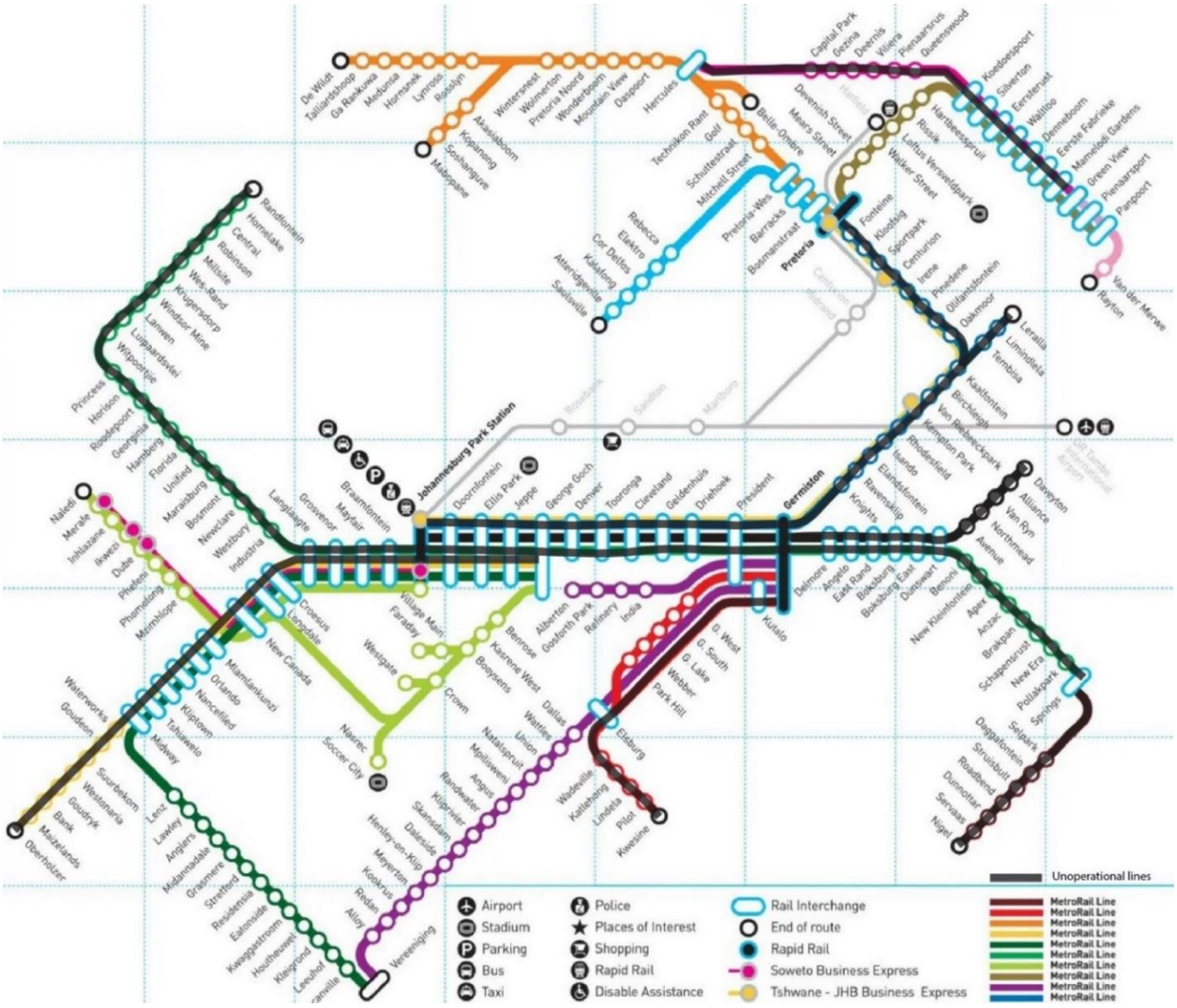

Figure 7: The Metrorail and Gautrain route map demonstrating the railway connections from Hatfield to a broader Gauteng region (adapted from Metrorail, 2023). It is evident that the Metrorail reaches significantly more geographic locations than the Gautrain. The Gautrain stations also stop at locations of significant economic wealth, such as Sandton and OR Tambo airport. It is important to take note that the lines highlighted in black are currently not operational (this data was obtained through information shared by Metrorail management on the Metrorail Facebook group as seen in Appendix 5).

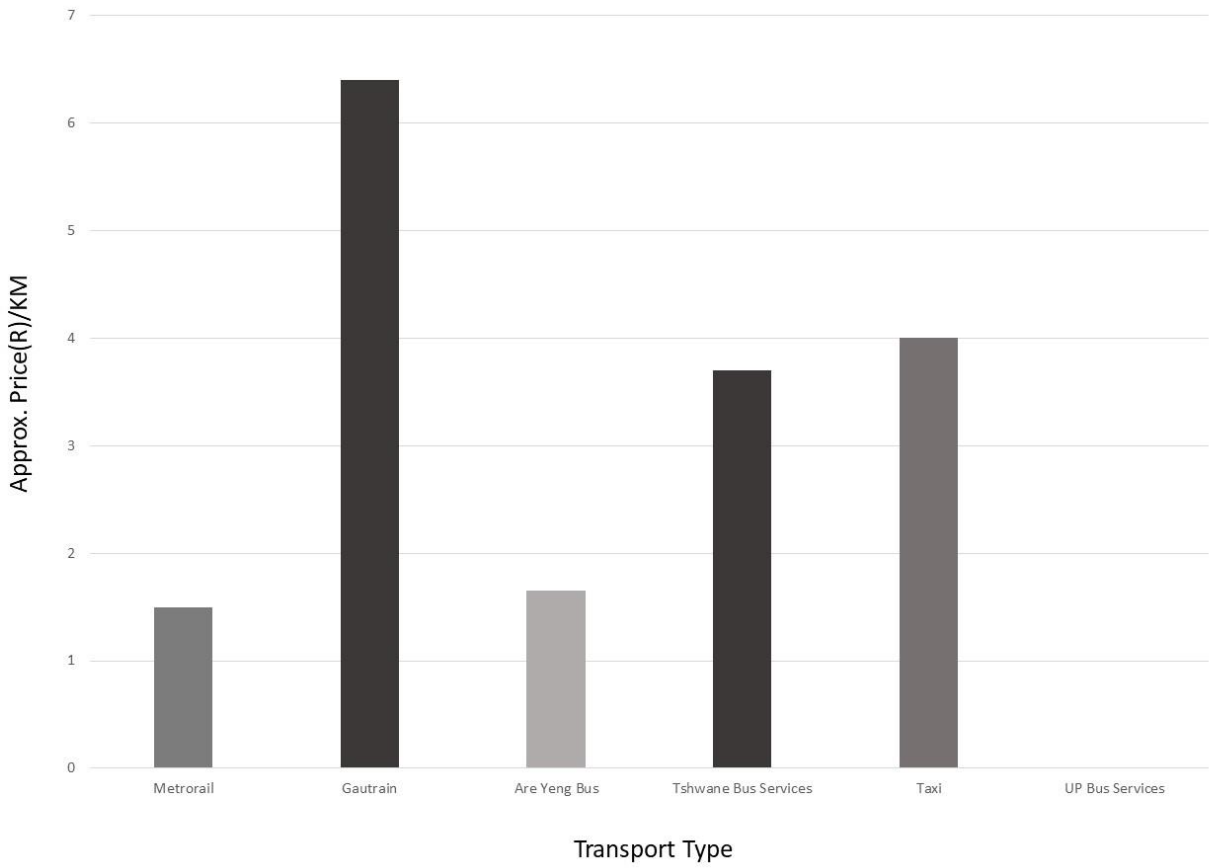

Figure 8: The approximate price per kilometer of the Gautrain system is significantly higher than the Metrorail system (MProf Research Group, 2023). This data was collected by visiting the public transport stations and asking ticket personnel what the current prices are.

Frequency of public transport and running times for Hatfield based stations

	Weekdays				Weekends			
	Times		Frequency of trips		Times		Frequency of trips	
Public Transport System	Operating Hours*	Peak Times**	Peak times	Off-peak times	Operating Hours	Peak Times	Peak times	Off-peak times
Gautrain	05:08- 21:24	AM: 06:00- 08:00 PM: 16:00-18:30	Every 10 minutes	Every 20 minutes	Sat & Sun: 05:30- 20:30	09:00-16:00	Every 20 minutes	Every 30 minutes
Metrorail: Rissik	04:51 - 19: 36	AM: 05:53-08:53 PM: 15:58- 17:28	Every 45 minutes	Every 90 - 120 minutes	Sat: 05:22- 19:41	AM: 05:20- 07:19 PM: 15:59 - 19:41	Every 60 mins	Every 120 minutes
					Sun: 06:11- 19:19	No obvious peak times	Every 120 minutes	

Figure 9: The frequency of the Gautrain is significantly more than the Metrorail system. This results in longer waiting times at the Metrorail stations (MProf Research Group, 2023). This data was collected from the Gautrain website and Metrorail ticket personnel at the station (Gautrain, 2023). The access to Metrorail information is limiting as it is not displayed in the train stations or on the Metrorail website.

It is evident that there are significant differences between the two train networks. These differences are considered as forms of exclusion from public transport infrastructure on a larger scale. Irrespective of these forms of exclusion, both train networks usually do not take commuters to their end destination. This results in the first/last mile of the journey from the respective train station to the final destination (the university) or vice versa. This section of the journey, either between the Metrorail stations and the university or the Gautrain and the university, is predominantly commuted by walking. These identified routes in Hatfield are investigated at a meso-scale (section 14.2.)

14.2 Meso-scale: The identified first/last mile routes in Hatfield between the Metrorail and Gautrain stations and the University of Pretoria

The routes identified in Figure 10, are the predominant first/last mile routes between the respective train station and the university campus. Only the predominant routes are analyzed to delimit the study and gain an understanding as to why these are the most predominantly used routes.

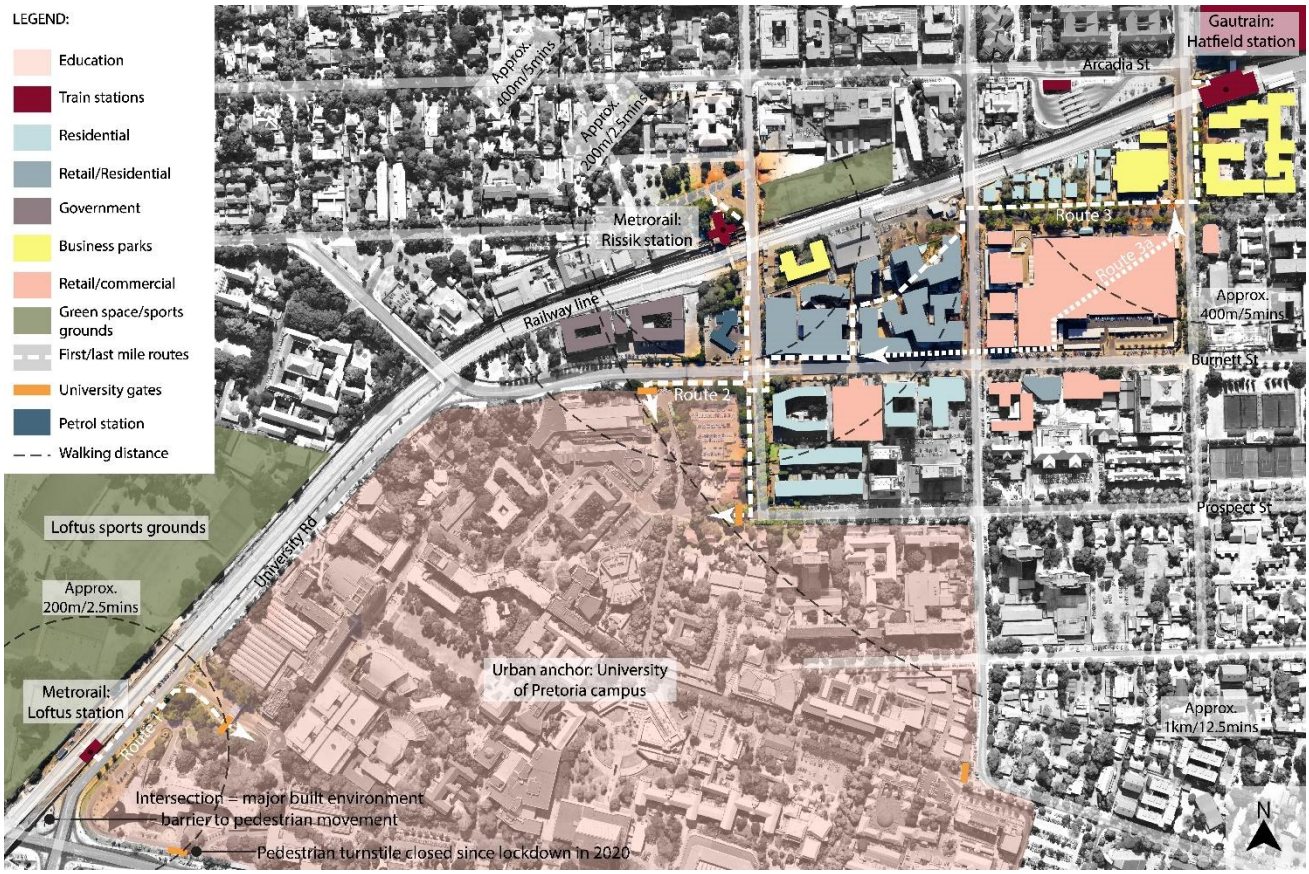

Figure 10: A map of Hatfield demonstrating the three most prominent first/last miles between the respective train stations and the university campus (Author, 2023). It is important to note that this map is indicative of current predominant routes and additional routes may emerge at different points in time. This map was informed by data collected from interviews, online surveys and visual observations of students commuting through Hatfield from the respective train stations to the university campus (refer to Appendices 7 to 11 and Figures 11 to 26).

All train stations are within a 15-minute walking distance to the university. These stations include the Metrorail's' Rissik and Loftus stations and the Gautrain's Hatfield station. The Metrorail's Hartebeesspruit station is excluded from the study as it was visually observed that student's use the Rissik and Loftus stations that are closer to the main campus. Students choose which Metrorail station to use depending on where they are commuting to on the main campus. This was determined by visual observation. Regardless of the train system type, the predominant use of transport to commute to university is between 5am and 8am, and the predominant time to travel from the university to their place of residence via the train networks is between 3pm and 5pm. These times influenced when future data was collected to optimize the study's data collection on site. It is evident that all identified routes were chosen by commuters due to a number of factors. The routes will be analyzed in the following section to identify similarities, differences, opportunities, constraints and other nuances along these movement corridors. These factors are recorded spatially.

14.3 Micro-scale: The first/last mile routes analyzed in terms of Figure 4.

The interviews indicated that the main mode of transport (Gautrain or Metrorail) is predominantly chosen according to its affordability and accessibility. However, after each commuter has transferred off of the main mode of transport, they need to reach their destination via the first/last mile section of the journey. This was observed visually and through interview answers. In terms of this study, feeder routes such as the Gautrain feeder bus is acknowledged but will not be included as the study is interested in the out-of-vehicle first/last mile experience. The study does acknowledge walking, cycling and skateboarding. However, while capturing data, no student was observed cycling or skateboarding the identified first/last mile. This may indicate the difficulty of transferring other transport devices such as bicycles or skateboards on main transport modes. The study therefore only observed student's walking this section of the journey. The three routes will be analyzed with regard to the identified themes and spatial components in Figure 4 in section 14.3.

14.3.1 Route 1: Loftus station to the university's pedestrian entrance on University road

From onsite visual observations and interview answers, Route 1 is the identified first/last mile between the Metrorail's Loftus station and the entrance to the university on University road. The commuting students exit the station and walk along the northern side of the road until they reach the sidewalk parking. This is where the road is crossed across 3 lanes. The sidewalk is then followed up a slight slope to the university pedestrian entrance and vice versa from the university gate to the station (as demonstrated in Figure 11).

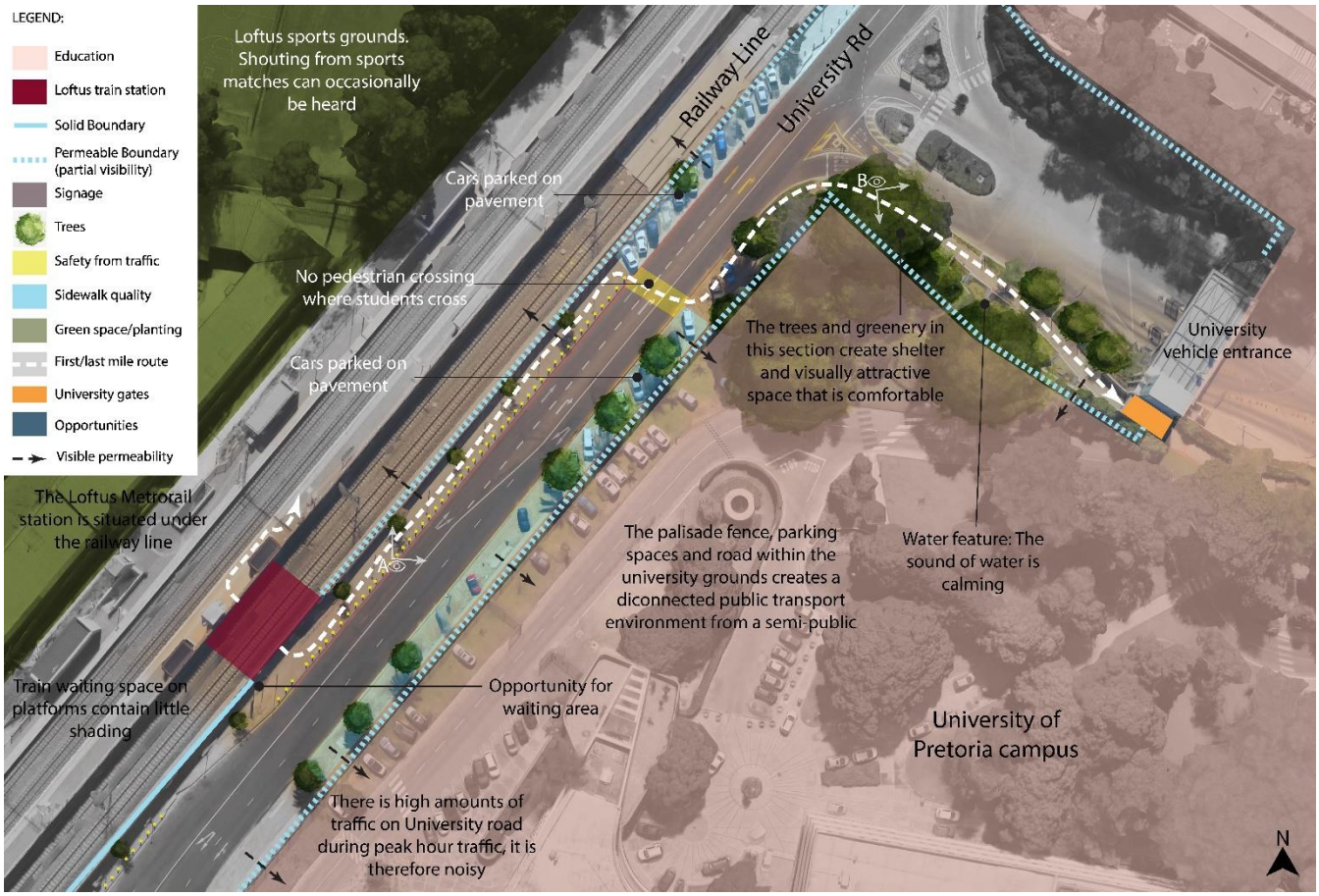

Figure 11: The identified first/last mile route 1 between Loftus station and the university pedestrian gate (Author, 2023). This map was informed by data collected from interviews, online surveys and visual observations of students commuting from the Loftus Metrorail train station to the university campus (refer to appendixes 5, 10 and 11 and Figures 12 to 13).

Figure 12 (Perspective A): Photographic data of University Road demonstrating the spatial experience of the first/last mile along route 1 (Author, 2023). The elements and spatial components highlighted in the image are emphasized in Figure 4 as first/last mile components that either hinder or facilitate the commuting experience. These are discussed in detail below.

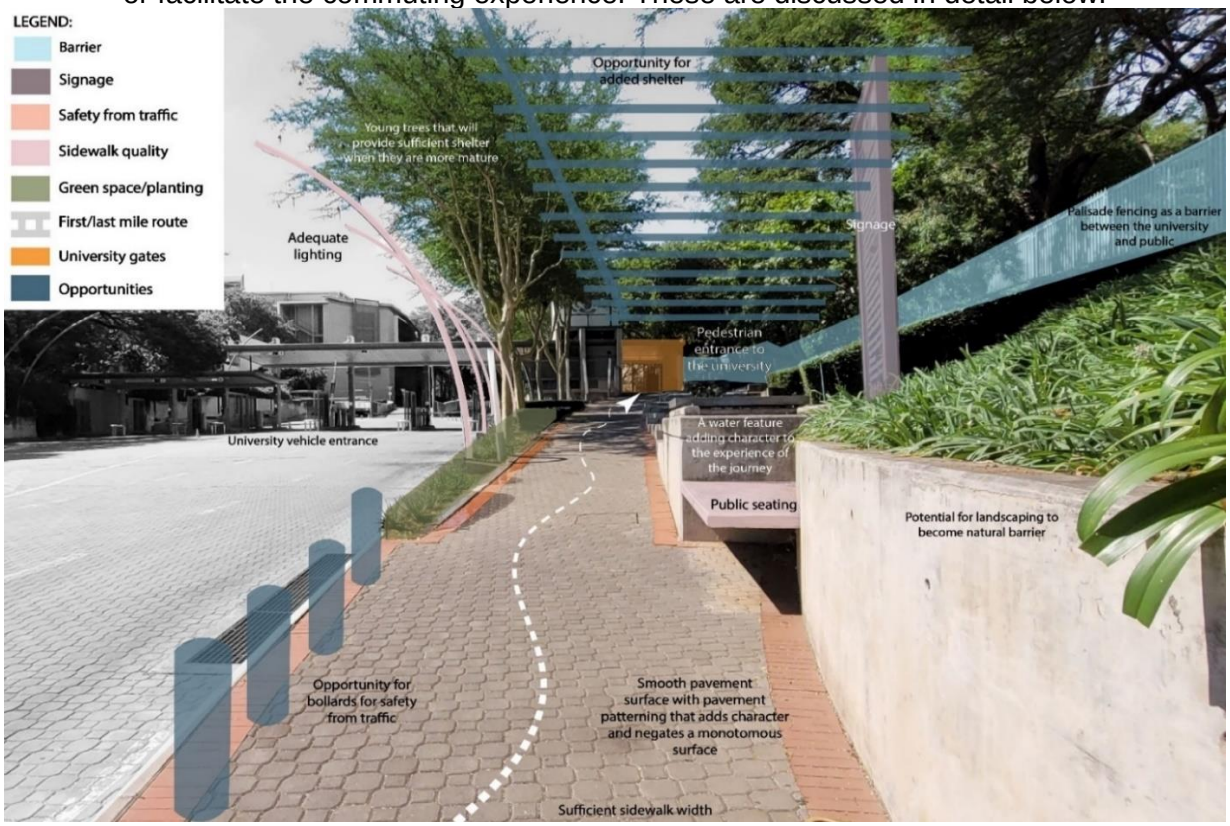

Figure 13 (Perspective B): Photographic data along the route to the university pedestrian entrance (Author, 2023). The elements and spatial components highlighted in the image are emphasized in Figure 4 as first/last mile components that either hinder or facilitate the commuting experience. These are discussed in detail below.

The following subsections are findings informed by visual observations, interview and online survey answers and information shared on the Metrorail Facebook group (Appendix 5) with reference to the first/last mile table of spatial components in Figure 4 and photographic data in Figures 12 and 13.

Comfort of waiting areas
The only resting/waiting space along the route is next to the water feature (Figure 13). However, this is only sufficient for one or two people. There are young trees along the sidewalk, however, they do not provide any shelter yet. While walking the route in summer, it was unpleasant in the sun and heat and when it rained student's used umbrellas to avoid getting wet. Student's only wait on the inside of the train station when waiting for the train on the journey back to their place of residence. The space next to the railway line does have seating which is sheltered by an overhead roof. However, the overhead does not provide shade in the afternoon when the sun is at an angle which makes the wait unpleasant and hot. The seating is steel and fairly comfortable for short waiting periods. There is no economic opportunities along the route to purchase food or drinks.

Safety
There are safety personnel present at the Loftus station, however, there are none along the route. There is sufficient lighting by streetlights lining the sidewalk. There is no CCTV monitoring along the route. Generally, students felt safe commuting along this first/last mile due to the short distance from the university gate and station, however, students avoid commuting when it starts to get dark due to a lack of people and passive surveillance.

Information access
At Loftus station there is insufficient information available with regard to train times, delays or prices. It is evident that a popular mode of communication for Metrorail users and management in Gauteng is a Facebook group, as there are approximately 39 500 users communicating daily on the platform. The communication is primarily commuters asking for information on train schedules, delays and ticket prices (Appendix 5). This is however limiting access to information to commuters that have an internet connection and the mobile application. It is therefore evident that there is a need for accessible information and communication with regard to the Metrorail management and commuters along this route.

Sidewalk quality/comfort
Student's that use private vehicles to commute to the campus park their vehicles on the sidewalk on the eastern side of University Road. Therefore, student's commuting along this first/last mile walk along the western side of University Road (as demonstrated in Figure 11), as the vehicles obstruct the pedestrian path at some points. The western sidewalk is wide, and the surface paving is even and comfortable to walk along. The sidewalks are clean and there are no obstructions.

Safety from traffic
The point at which student's cross the three lanes is highly unsafe. There is no pedestrian crossing across the 2-way road or an intersection to cross along this route. Therefore, student's cross when they feel it is safe to do so. This is a challenge during morning and afternoon traffic. The sidewalks are however lined with bollards that keep pedestrians safe from traffic while they are walking alongside the road.

Distance/time
The distance between the station and the university pedestrian entrance is approximately 210 meters which is approximately 5 minutes. There are no feeder routes from this station to the university.

Land uses
Along the western sidewalk, the railway line acts as a strong barrier between the Loftus sports grounds and University Road. Along the eastern sidewalk, there is palisade fencing isolating the university campus from the public. These barriers divide the public and semi-public land uses and

prevent interaction between the two. While commuting along this route, students feel disconnected from the surrounding urban fabric and isolated to the movement corridor by these barriers.

Costs
The daily budget of people commuting via the Metrorail is between R11.00 and R20.00 which is noted as affordable by commuting students.

It is evident that although Route 1 is a short first/last mile, it is not a journey that interacts with the surrounding urban context or that is lingered or socialised along. It is not a safe route to commute during peak hour traffic times or at night and is unpleasant during hot and rainy days. However, these discontents reveal opportunities for intervention. It can be concluded that this first/last mile route demonstrates factors and spatial components that both hinder and facilitate the commute to education.

14.3.2 Route 2: Rissik station to the university's pedestrian entrance on Burnett Street

From onsite visual observations and photographic evidence, Route 2 is the identified first/last mile between the Metrorail's Rissik station and the university's pedestrian entrance on Burnett Street. Student's exit Rissik station and walk along the western sidewalk of Festival Street and cross Burnett Street at the intersection. The southern sidewalk of Burnett Street is commuted along until the university's pedestrian entrance is entered as demonstrated in Figure 14.

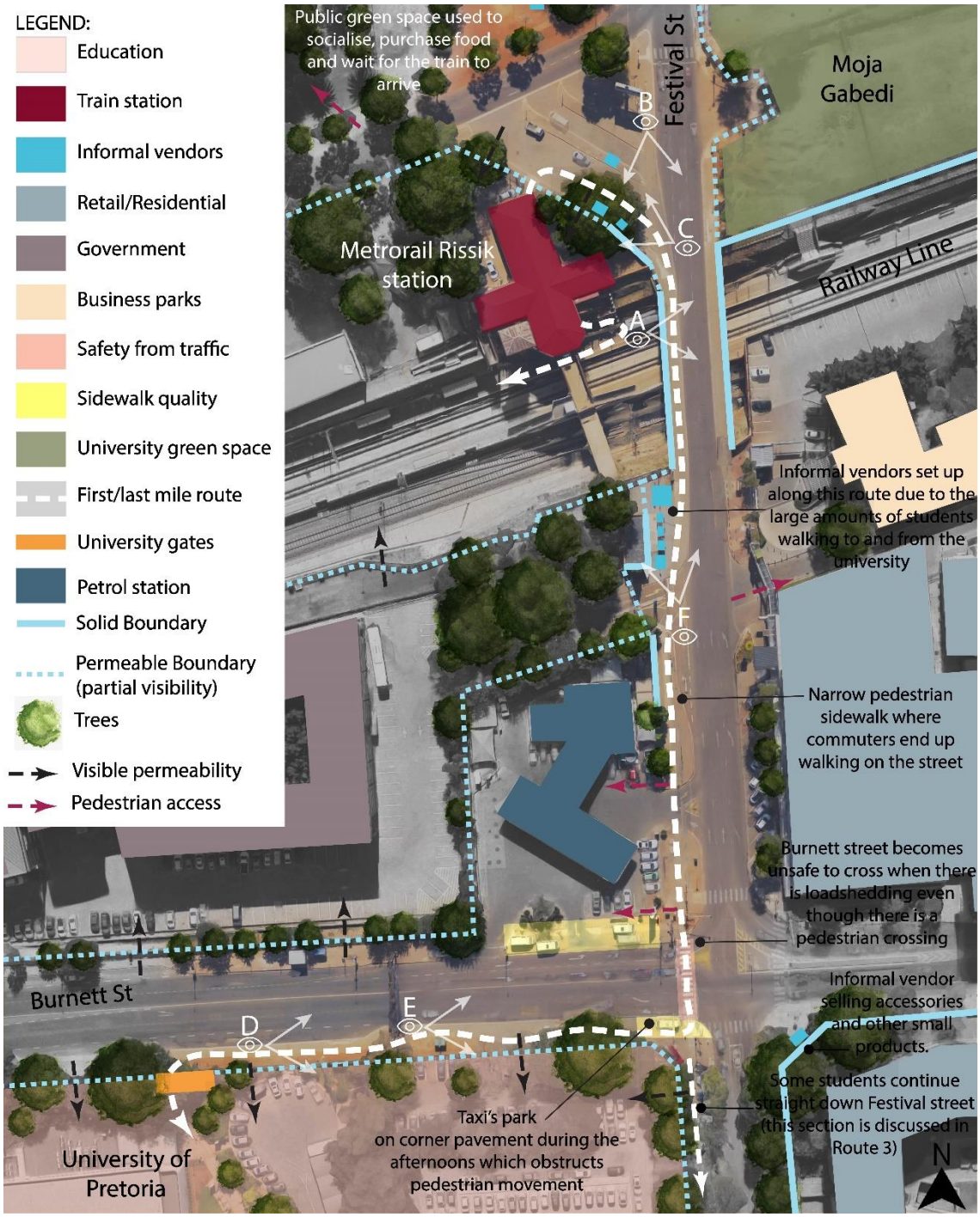

Figure 14: The first/last mile identified between Rissik station and the university's pedestrian entrance on Burnett Street (Author, 2023). This map was informed by data collected from interviews, online surveys and visual observations of students commuting from the Rissik Metrorail train station to the university campus (refer to appendixes 5, 10 and 11 and Figures 15 to 20).

Figure 15 (Perspective A): Photographic data of Rissik station during morning peak hour demonstrating the large influx of people that exist the train into Hatfield (Author, 2023). Student's experienced difficulties with crowding during peak hours.

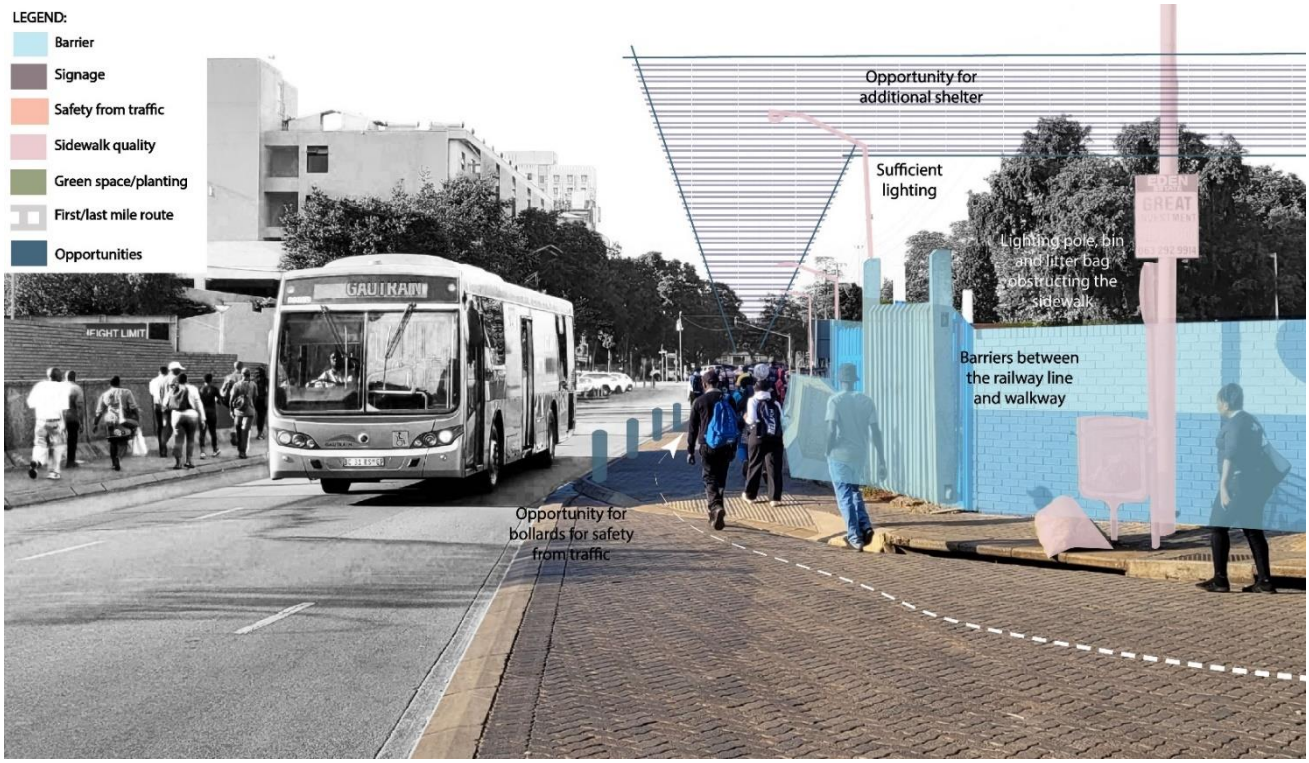

Figure 16 (Perspective B): Photographic data outside Rissik station demonstrating the high density of people commuting along this identified first/last mile (Author, 2023). This large influx of commuters (especially students) informed the identified first/last mile route in Figure 14 as it was the predominant route used to commute between the station and campus. This influx of commuters occurs during peak hours.

Figure 17 (Perspective C): Photographic data outside Rissik station in the afternoon while students are commuting back to the station (Author, 2023). There are informal vendors selling food, people standing around socialising and people playing soccer. There was also music playing which created a vibrant atmosphere along this first/last mile route. There is a relaxed and vibrant atmosphere created by these factors which facilitated the commuting experience.

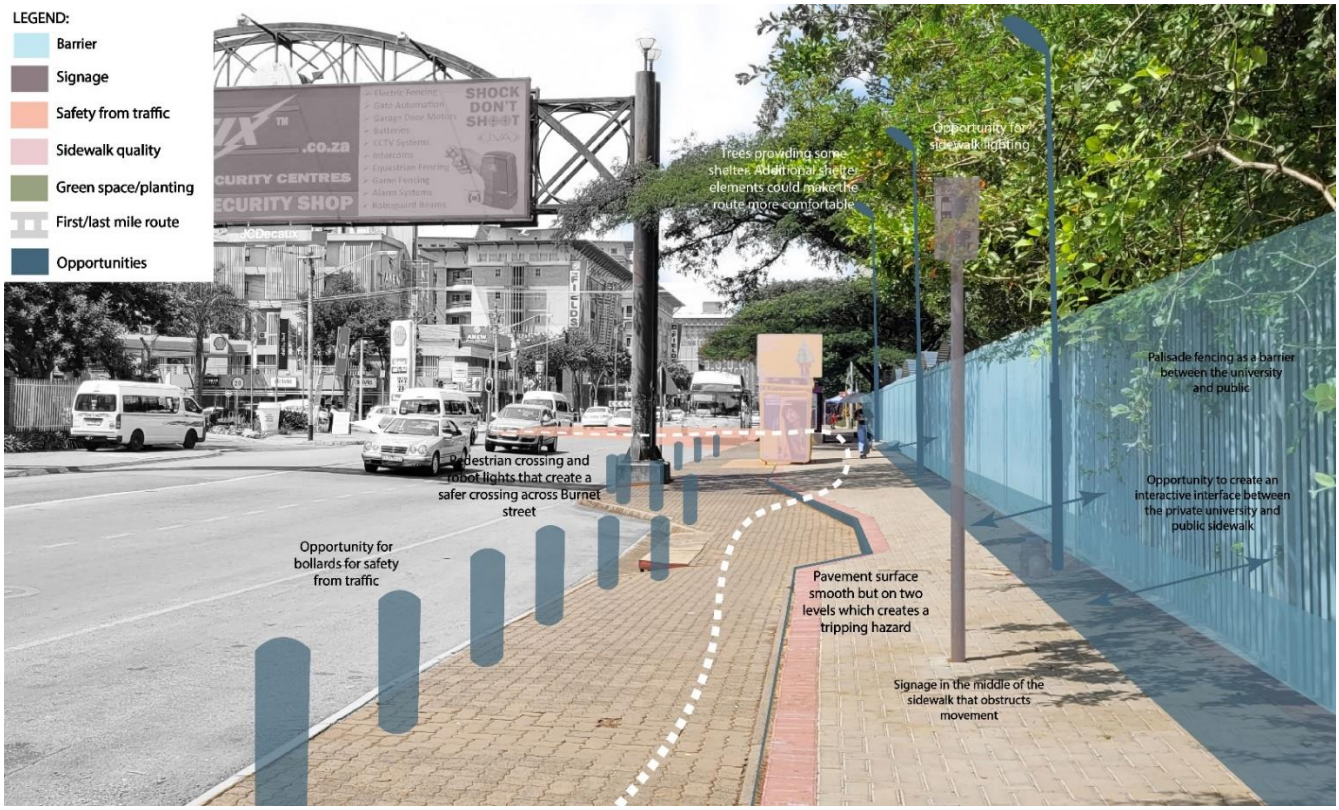

Figure 18 (Perspective D): Photographic data along Burnett Street demonstrating the lack of protected sidewalks and the barrier between the university and the public (Author, 2023).

Figure 19 (Perspective E): Photographic data along Burnett Street demonstrating how taxi's park on the sidewalk to wait for passengers in the afternoon and therefore obstructing pedestrian movement (Author, 2023). A shared use of the stop/go BRT bus lane 20 meters down the road could improve this visible need.

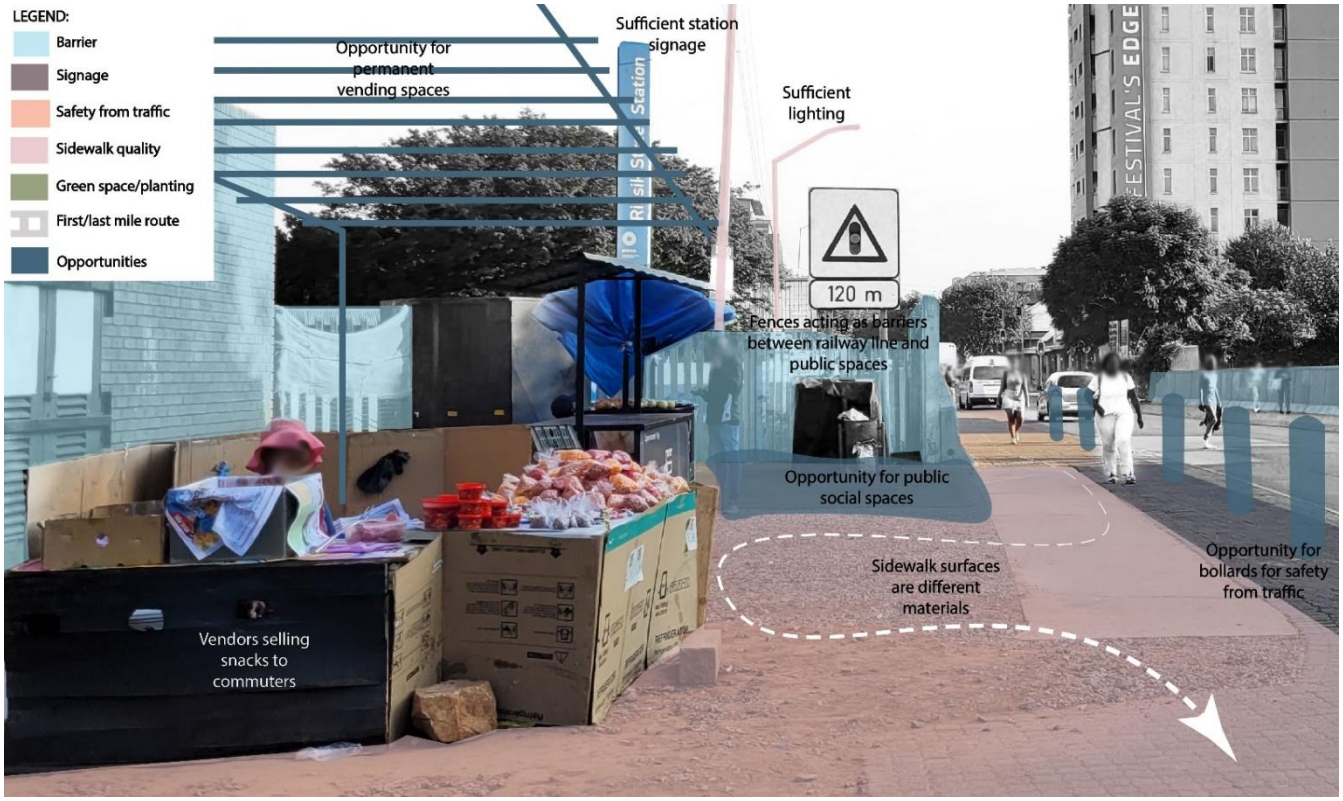

Figure 20 (Perspective F): Photographic data along Route 2 where student's purchase from informal vendors (Author, 2023).

The following subsections are findings informed by visual observations, interview and online survey answers photographic observations and information shared on the Metrorail Facebook group (Appendix 5) with reference to the first/last mile table of spatial components in Figure 4.

Comfort of waiting areas

This route contains numerous waiting areas around Rissik station. These waiting areas are informal and occur under trees, on grass spaces, on sidewalks alongside paths of movement and where vendors are selling food. The trees provide shelter from the sun. It was also observed in the afternoon, commuters and local residents play soccer in the green space adjacent to the station. The route does not provide much shelter from outdoor elements and therefore commuters need to use umbrellas if it rains. On weekdays between 3pm and 5pm, there are large groups of commuters waiting next to the railway line to catch the train back to their place of residence. During this peak commuting time there is insufficient seating in these waiting areas and a lack of shelter from sun and rain.

Safety

All the streets are lined with streetlights and the surrounding residences light up the space in the evenings and act as passive surveillance. Safety personnel were also present along the route until about 5pm. Generally, student's felt safe commuting along the route, however, they avoid commuting it when it starts to get dark.

Information access

At Rissik station, there is insufficient information available with regard to train times, delays or prices. This information is obtained by communicating with ticket personnel which is difficult when there is queuing during peak times. At the stations digital information boards are present, however, they do not work. It is evident that there is a need for information access along this route.

Sidewalk quality/comfort

The sidewalks along the route have flat paved surfaces. In the afternoon taxi's park on the sidewalk corner to wait for passengers due to inadequate provision for taxi systems. This creates a safety

hazard as commuters crossing the street at the intersection cannot see oncoming cars and block pedestrian movement. The route is generally comfortable as there are places to purchase food and drinks and socialise.

Safety from traffic
The sidewalk along the entire route does not contain bollards or any other feature that acts as a safety barrier between the road and sidewalk. Festival Street is a one-way street which adds a layer of safety as pedestrians only need to be concerned with one-way traffic. There is a large pedestrian crossing along the route crossing Burnett street and traffic lights indicating when it is safe for commuters to cross. From around 2pm, however, taxis stop on this corner sidewalk and obstruct pedestrian movement. This is a safety hazard as pedestrians cannot see oncoming traffic. There is also a Tshwane bus stop along the route which does not have any barriers between the road and waiting area.

Distance/time
The approximate distance of the route is 350 meters and the approximate time to walk the route is 7 minutes. There are no feeder routes from this station to the university.

Land uses
There are various land uses along this route. Outside Rissik station and along Festival Street, vendors stated that they trade in these specific areas as student's purchase food from them while they are commuting between the station and university. On the corner off Festival and Burnett Street there is also a petrol station, however, no student's entered the petrol station shop while commuting. The university borders the section of the route along Burnett Street. A palisade fence acts as a barrier between the public sidewalk and semi-public institution. Therefore, it is evident that the only interaction students had with the surrounding land uses was with the informal vendors and green social spaces.

Costs
The daily budget of people commuting via the Metrorail is between R11.00 and R20.00 and there are no feeder trips from the main transport mode to the university and therefore no additional costs.

Although the commute is short and hindered by safety concerns, a lack of access to information and fences that act as barriers, informal land uses such as vendors and spaces to socialise connect students to the surrounding context. Spatial components such as trees, open green spaces, active street edges and flat commuting surfaces facilitate the commuting experience and connect students to the surrounding context. These spatial components create spaces of hard and soft infrastructural interactions as they create spaces for people to socialise and engage with the urban context.

14.3.3 Route 3: The Gautrain's Hatfield station to the university's pedestrian entrance on Prospect Street

From onsite visual observations and photographic evidence, Route 3 is the predominant first/last mile between the Hatfield Gautrain station and the university campus pedestrian gate on Prospect Street. Route 3a is the predominant route taken when it is raining as it passes through the Hatfield Plaza which is fully covered. The routes will be analyzed further in Figure 21.

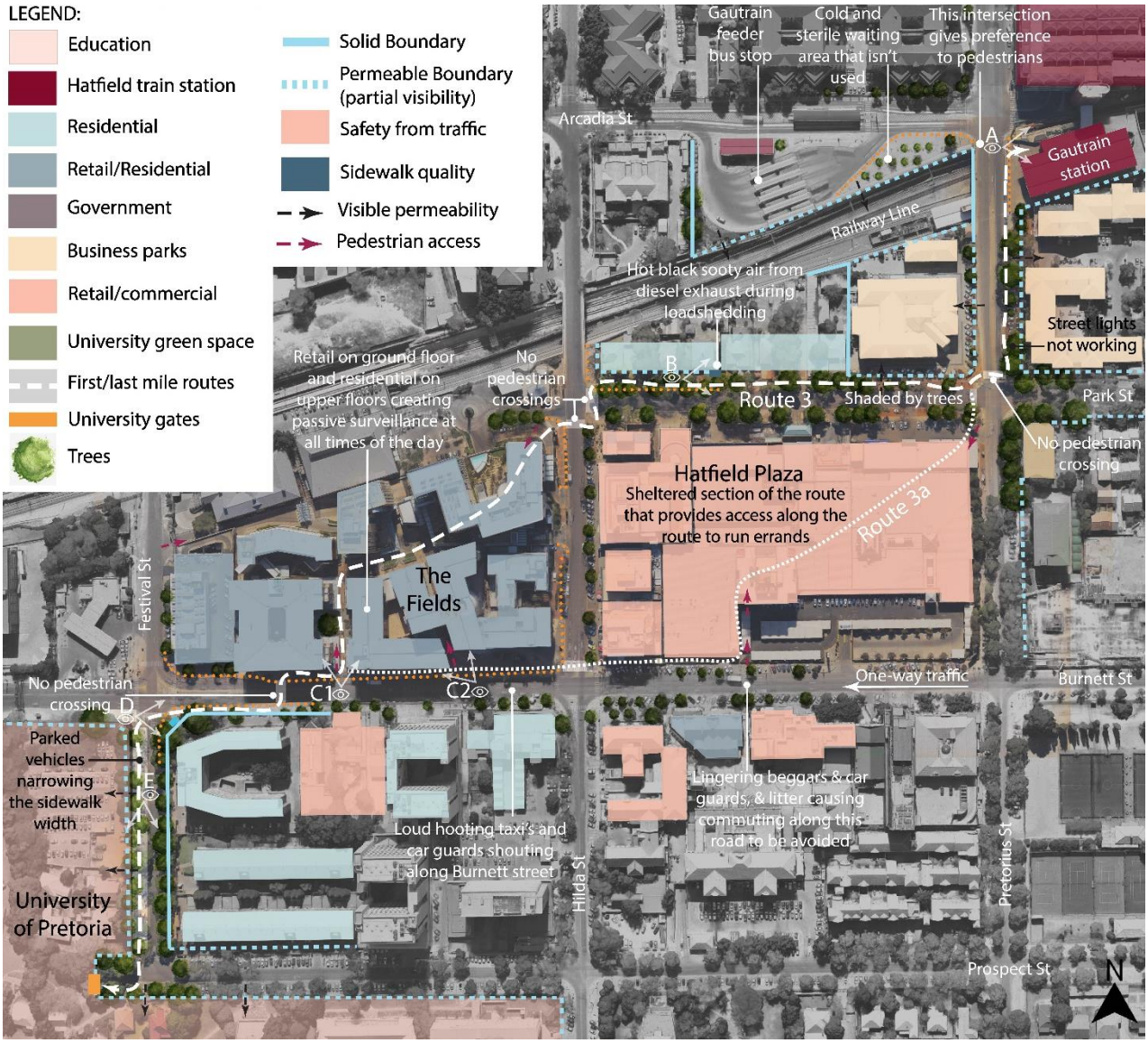

Figure 21: The first/last mile route identified between the Gautrain Hatfield station and the university campus (Author, 2023). Route 3 is the predominant route used by student's commuting. However, Route 3a is the predominant first/last mile used when it rains. This map was informed by data collected from interviews, online surveys and visual observations of students commuting from the Gautrain station to the university campus (refer to appendixes 7 to 11 and Figures 22 to 26).

Figure 22 (Perspective A): Photographic data of the Gautrain station entrance demonstrating a desolate and sterile public waiting area (Author, 2023).

Figure 23 (Perspective B): Photographic data along Park Street demonstrating the interface of student residences and sidewalk (Author, 2023).

Figure 24 (Perspective C1 and C2): Photographic data demonstrating the pedestrian-friendly environment of The Fields on ground level (Author, 2023).

Figure 25 (Perspective D): Photographic data of the informal vendor that student purchase from along Route 3 (Author, 2023).

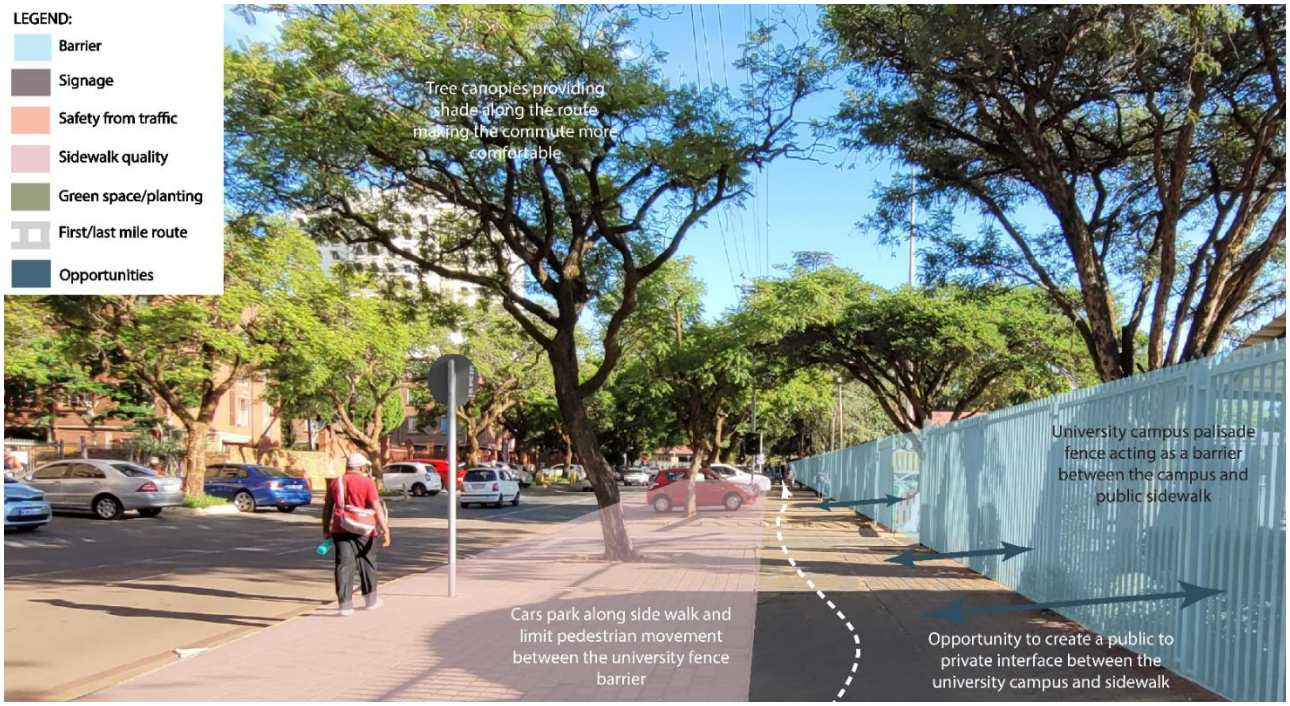

Figure 26 (Perspective E): Photographic data of the condition between the isolated university campus and the public sidewalk along Festival Street (Author, 2023).

The following subsections are findings informed by visual observations, interview and online survey answers, photographic observations and information shared on the Metrorail Facebook group (Appendix 5) with reference to the first/last mile table of spatial components in Figure 4.

Comfort of waiting areas

Student's commuting along this first/last mile indicated that they do not wait anywhere along the route, besides for at the Gautrain station when waiting for the train to arrive. The waiting area in the Gautrain station was described as cold and sterile. The waiting time is approximately 10-minute intervals at peak times and 20-minute intervals off-peak; therefore, this space is not lingered in for

long. The entrance to the Gautrain station has concrete benches that further add to the cold and sterile atmosphere. These concrete benches are also present at the Gautrain feeder bus area. The waiting area to get onto the Gautrain is under the station building and is therefore completely sheltered from external elements. The Gautrain feeder bus waiting area is surrounded by trees that provide shelter. There are no economic opportunities to buy food or drinks near these waiting areas. No food or drink is allowed on the train platforms or on the trains themselves. This may benefit the cleanliness of the train network, but it prevents comfort along the journey. The Gautrain also has public ablutions available for users.

Safety
There are numerous safety personnel present in and around the Gautrain station. It is evident that a factor of this route being the most predominant route chosen by commuting students was the fact that they did not feel safe along Burnett Street due to the presence of beggars and car guards. It was also evident that the streetlights along Pretorius Street are not working and therefore students avoid walking back to the Gautrain station when it starts getting dark. The rest of the route is observed to be well lit, and the presence of safety personnel are dispersed amongst the Hatfield roads. Mixed-use spaces along the route added a layer of passive surveillance and made students also feel safer.

Information access
There is sufficient signage in and around the Gautrain station. The Gautrain feeder bus information is displayed on the bus terminals directly outside of the station entrance.

Sidewalk quality/comfort
The sidewalks along this route are reasonably flat and are of sufficient width. For the majority of the route, trees line the sidewalks and provide shelter. The trees and planting along the route connect commuters to the natural environment and create a positive, calming experience. Outside of student residences, there are generators along the sidewalk that blow a hot black sooty air from the diesel exhaust during electricity outages into the pedestrian walkway. This creates an unpleasant experience. The Fields is a common pedestrian node for commuters to pass through to avoid walking along Burnett Street. The sidewalk along Festival Street is more often than not lined with private vehicles making the pedestrian path narrow. A palisade fence acts as a barrier between the university campus and the public sidewalk and isolates commuters to the movement route.

Safety from traffic
For the majority of the route, there are bollards and concrete planters that act as barriers between the road and sidewalk. The sidewalk along Festival Street is often lined with parked cars which also act as a barrier from commuting cars. Along this route, there are only pedestrian crossings along Festival Street. Generally, the student's interviewed do feel safe walking alongside the roads in Hatfield, however during loadshedding they do not feel as safe as cars do not always stop at intersections.

Distance/time
The distance between the Gautrain station and the identified university gate is approximately 1 kilometre and takes approximately 15 minutes to walk.

Land uses
There are numerous land uses along this route. Along Pretorius Street there are office parks that border both sidewalks and remain isolated from the public environment by fences. Along Park Street, student residences line the sidewalk, however, the use of 1 meter high brick walls, glazing on ground floor for visible permeability and the use of greenery creates an experience of connection to the land use. The block permeability of The Fields allows uses to walk through the public, retail ground floor and purchase from the stores through this section. This land use benefits these commuter's as it provides a safe corridor of movement, and the buildings provide shelter. There is an informal vendor on the corner of Burnett and Festival Street that student's buy bags and

umbrellas from while commuting. Along Festival Street, a palisade fence acts as a barrier between the university campus and the public sidewalk.

Route 3a is mostly used when it is raining as Hatfield Plaza offers shelter. It was also observed that commuters pass through this centre to purchase items from the shops and eateries along the journey. The accessibility of various stores along a path of movement is convenient to commuters to run errands.

Costs
All student's using the Gautrain network to commute to Hatfield indicated that their daily budget for transport is over R91. To use the Gautrain feeder bus to the university a commuter needs to have at least R32 on their Gautrain card. It was noted that student's preferred to commute via walking to campus than using the feeder bus as it was free, and the feeder bus was not always on time. The bus service was used more often when it is raining though.

From the data collected, it is evident that student's commuting via the Gautrain experience a sterile waiting environment at the station that is disconnected from the surrounding context. However, it is also evident that the first/last mile demonstrates sections that are extremely integrated with the surrounding context and land uses. It is evident that mixed-use pedestrian spaces create a comfortable environment that facilitates the first/last mile experience. The Fields is an excellent urban example of hard and soft infrastructural components facilitate the commuting experience. Spatial components identified in this urban space that facilitate the first/last mile is semi-sheltered pedestrian spaces that are surrounded by mixed land uses for passive surveillance at different times of the day and an interactive public ground floor of retail spaces. Greenery, seating and barriers to traffic also enhance the space. There is also an alternative first/last mile route to the university campus via the Gautrain feeder bus.

Regardless of the first/last mile route taken, all student's demonstrated difficulties of not being able to work late in the evenings due to safety concerns and the train networks stop operating. The Gautrain stops operating at approximately 9:30pm and the Metrorail trains stop operating at around 7:30pm during weekdays. The student's that commute via the Gautrain stated that if this mode of transport is not available, their alternative mode of transport is a private vehicle. However, the alternative mode of transport for commuters using the Metrorail is either walking, cycling or using a taxi (which is resultantly more expensive). It is evident that student's commuting via the Metrorail have a significantly lower daily transport budget and therefore cannot afford to use the Gautrain system. It was observed that both student's commutes on both train systems took an average travel time of between 31 minutes and 60 minutes. All student's indicated that they use the specific mode of transport because it is the most affordable, reliable and convenient option currently available to them. Suggestions that were voiced by student's commuting via these transport systems that would make the commuting experience better included tracking the transportation positions on a mobile application or screen at the waiting area, to see how long the train is away and adding trains that operate later.

15.0 Discussion: Analysis of data and findings (urban sample)

Through analysing the urban sample and literature reviewed, it is evident that commuting to and from places of education is not always a smooth journey through the current spatial dysfunction of the urban system in South Africa that is still evolving from historical spatial injustices. Tertiary institutions are often located in distant cities and like the University of Pretoria, act as an urban anchor that attracts a large number of student's to commute to and from the area daily. Transport infrastructure systems have been put in place to negate spatial injustices such as the distant location of educational opportunities. However, these hard infrastructural systems present forms of inequality on macro, meso and micro-scales for student's commuting to and from places of education. There is a gap in knowledge on the experience of student's commuting to and from

universities in South Africa and opportunities to improve pedestrian interfaces and socio-spatially provisions.

On a macro-scale, the data in the urban sample revealed that both the Gautrain and Metrorail train systems connect Hatfield to distant geographic locations. However, the Gautrain connects locations of high economic standing (Sandton) and the Metrorail connects areas of lower economic standing (Sausville and Mabopane). This finding demonstrates that even though both systems connect distant geographic locations, the Metrorail is more accessible to lower income commuters and the Gautrain to higher income commuters. This is evidently a nuance of inequality with regards to accessibility of the two systems. Regardless of the accessibility of each system, both railway systems are used by student's commuting to and from Hatfield.

On a meso-scale, the data in the urban sample revealed that both train systems demonstrate inequalities with regard to efficiency, reliability and affordability. The Gautrain is distinctly more expensive than the Metrorail system and therefore limits access to lower income groups. The Metrorail is also more unreliable and inefficient as there are significantly longer waiting periods between trains and there are often train delays that are not communicated to commuters. The Metrorail trains are crowded during peak commuting times and there is not enough seating resulting in commuters having to stand their whole commute. Whereas there is always sufficient seating on the Gautrain, even during peak times.

The Gautrain system is clean as eating or drinking is not allowed on the train, however, the Metrorail system does not have such strict rules and one can eat or drink while commuting. This results in a more comfortable commute. The accessibility and coordination of the Gautrain is much more efficient, as although you need to purchase a Gautrain card and load money onto the card, the process of accessing the train platforms can be achieved without consulting any Gautrain personnel. There are also operating and accurate digital displays of train times and platform locations. Whereas the Metrorail station systems are inefficient due to ticket scanning machines and information display boards not being operational and tickets being purchased manually from a ticket seller. Resultantly, long queues and crowding forms which negatively impacts commuters journeys. While each system has factors that hinder the commuting experience and can be described as nuances of inequality, it is evident from the urban sample that the Metrorail is the more affordable option and the Gautrain is the more efficient and reliable option. After commuting on either of these train systems all student's needed to complete the first/last mile to reach the university campus or vice versa. The Gautrain station in Hatfield presented a significantly longer first/last mile route than the Metrorail stations.

On a micro-scale, the data collected on the experience of the identified first/last mile routes was analyzed in terms of the themes and spatial components demonstrated in Figure 4. The findings of the urban sample data is discussed according to the themes.

Comfort of waiting areas

Route 3 was the only route that provided waiting and public seating areas along the first/last mile at The Fields. It is, however, more necessary as the route is longer than the other first/last miles. The pedestrian-centred environment at The Fields was the main reason this first/last mile route was used. Factors and spatial components that made the waiting area more comfortable was the inclusion of greenery, seating, semi-sheltered spaces from roof overhangs, mixed land uses, interactive interfaces on ground floor and a balance between indoor and outdoor spaces. These factors created waiting areas that promoted social interactions and lingering of people. Factors and spatial components that made waiting areas less inviting is a lack of shelter and greenery, cold materials such as concrete and spaces with inactive building interfaces.

Safety

It is evident that the presence of streetlighting, security personnel and CCTV monitoring creates a sense of security along the first/last mile routes. Route 3 demonstrated sufficient safety personnel

and measures as the interior and exterior Gautrain spaces are heavily surveillance by security personnel. This created a sense of comfort and peace of mind for students using this system. This demonstrates an opportunity for improvement for Metrorail stations as they do not have sufficient surveillance. It is also evident that routes are chosen due to safety concerns in certain areas where there are beggars and car guards. Passive surveillance through mixed-use spaces and active ground floor interfaces is also a key factor to creating safer first/last miles.

Information access
Easy access to information on train times, delays and ticket prices is a key factor to a positive commuting experience. The Metrorail stations have the hard infrastructure to communicate this information, however, it remains not operational. The soft infrastructural means of communicating information on online platforms such as Facebook, facilitates further injustices as information is limited to commuters with the application and internet connection. This highlights the need to repair the hard infrastructure at the Metrorail stations.

Sidewalk quality/comfort
Sidewalk factors and spatial components that facilitate the first/last mile quality include wide sidewalks, greenery, semi-sheltered spaces by trees or building overhangs, smooth surfaces, interactive interfaces, active edges and protection from traffic such as planters or bollards. It was evident that commuters tend to choose routes that have better-quality sidewalks. Informal vendors created interactive edges and soft infrastructural interactions along solid land use barriers along Route 2 which also further enhanced the experience. The inclusion of natural environmental elements such as greenery and water also enhanced the commuting experience and comfort as it is visually appealing, relaxing and connects people to the surrounding environment. Factors and spatial components that hindered the first/last mile experience included solid barriers between land uses which disconnected commuters from the surrounding context and objects obstructing movement.

Safety from traffic
It is evident that where possible, commuters choose routes that minimize contact with vehicles. Spatial components and factors such as bollards, raised planters and road crossings facilitated the pedestrian experience by creating a layer of safety. It is evident that there are sections along students first/last miles that do not contain these factors and unforeseen events like power outages, traffic and speeding vehicles further hinder the experience. Taxi's parking on sidewalks also create dangerous situations for students commuting. Therefore, these sections require immediate intervention to prevent possible accidents.

Distance/time
All 3 first/last mile routes were within walking distance to the university; however, students have alternative route options from the Gautrain station as it is the furthest distance. Students therefore needed to plan their routes to consider the walking time or feeder bus schedule that included additional costs. Even though all the routes were relatively short, feeder options such as the Gautrain feeder bus created a better experience and option when it rained or started getting dark. This could be considered for the Metrorail student commuters.

Land uses
It is evident that the routes that interacted more with surrounding land uses had a more positive experience as commuters were more connected to the surrounding urban context and more soft and hard infrastructural interactions were noted. Informal vendors that occupied land use fences created interactive boundaries which allowed for quick purchases along movement routes. The Fields created a mixed land use arrangement that allowed commuters to move through the city block on ground level. This land use arrangement is highly successful as it creates a safe and active pedestrian environment with passive surveillance at almost all times of the day and night. The retail stores on the ground floor created active building interfaces that allowed commuters to run errands along the route. It is also evident that factors and spatial components such as trees, open green spaces and open spaces along movement routes create spaces for people to socialize and relax

while waiting for transport. These spaces demonstrated spontaneous and informal activities of soft infrastructure around hard transport infrastructure. It was also evident that along all 3 routes were sections where boundary fences isolated commuters to the movement path, therefore, creating experiences of urban exclusion. These negative experiences and isolated movement paths demonstrate spatial injustices and inequality in the urban form.

Through analysing hard and soft infrastructure interactions with regard to transport infrastructure, it is evident that there are nuances of inequality and spatial injustices experienced by students commuting to the University of Pretoria on a macro, meso and micro-scale. On a macro-scale, there are nuances of inequality with regard to unequal access of different economic areas to the Gautrain and Metrorail systems that connect geographically distant locations. On a meso-scale there are nuances of inequality with regard to the affordability, efficiency and reliability of the Gautrain and Metrorail train systems. On a micro-scale, there are nuances of inequality with regard to factors and spatial components that hinder the first/last mile and out-of-vehicle experience of the commute. These spatial components and factors include unsafe spaces of movement and commuter disconnection to the surrounding urban environment. However, spatial components and factors that facilitate the commuting experience are spaces that are mixed-use, have interactive interfaces with boundaries and buildings, safe from vehicular movement, are semi-sheltered and a mixture of hard and soft scaping with shops, services and vendors present for improved passive surveillance. These interactions between hard and soft infrastructure along first/last miles revealed that spaces with more factors that facilitate the commuting experience are more successful. As students felt more connected to the surrounding urban context and had a more positive commuting experience to the university. Whereas students are more disconnected from the surrounding urban environment, isolated to the movement route and generally had a negative experience in spaces that included more spatial components and factors that hinder the first/last mile.

These nuances of inequality were made evident through the study of soft infrastructural interactions with hard infrastructural forms that have been placed into the urban context. These not only hinder the experience of students commuting to the basic right of education, counteract the intended purpose of hard infrastructural systems negating past spatial injustices in the country but also affect the emergent pattern of movement through Hatfield (as seen in the Gautrain first/last mile route). However, there are also nuances of equality identified along first/last mile routes, such as The Fields, that is recommended to be used as an example for future urban planners and architects. The subjective experiences and interactions of hard and soft infrastructure patterns were not portrayed in quantitative desktop data, maps and urban frameworks. However, through the layered analysis of quantitative and qualitative primary and secondary data, and a grounded theory approach, an in-depth understanding of the study context on different scales was achieved. The data analysis concludes that there are nuances of inequality on various scales that is imposed by urban transportation, public spaces and pedestrian mobility infrastructure on students commuting to tertiary education in Hatfield, South Africa.

The findings in this study build onto access to education, emergent patterns of movement and first/last mile literature and knowledge in the urban transportation infrastructure discourse. The analysis of data confirms findings from international and local literature previously mentioned in section 13 (Venter et al., 2022; Lesh, 2013; Park et al., 2021; Coffel et al., 2012; Venter, 2020). However, this study achieves a more thorough investigation through the grounded theory approach of hard and soft infrastructural interactions and adds to existing first/last mile knowledge by including the theme of 'land use' that was not used in previous first/last mile research. The inclusion of the theme, land use, added value to understanding interaction (or a lack of) between commuters and surrounding environments and therefore it is recommended to also be used in future studies. Existing research on the topic in South Africa is predominantly subjective. This study includes an objective and layered understanding on various scales as well. A holistic understanding was achieved through a layered analysis of identifying nuances of inequality on a macro, meso and micro-scale with regard to students commuting and transport infrastructure. The data from this study

emphasizes the importance of understanding first/last mile and out-of-vehicle experiences to negate spatial injustices and inequalities, encourage more people to commute via public transport to places of education and make urban planners and architects aware of public transport infrastructure areas that need improvement for the whole system to be sustainable and inclusive.

16.0 Conclusion

It can be concluded that access to education is recognized as a universal right that allows individuals to gain social and economic development. This is critical to negate South Africa's extreme inequality with regard to wealth inconsistency and unjust past. Systems have been put in place to negate these injustices, such as the Metrorail and Gautrain railway systems that connect geographically distant locations and student's to places of education. However, through investigating these hard infrastructural systems in relation to soft infrastructural systems through an urban sample, it is evident that they generate other forms of inequality that hinder the intended purpose of the system.

Commuting to places of education is the second largest reason people commute in the country and through the study it is evident that many student's experience the spatial dysfunction of the commute daily. The urban sample revealed that the Gautrain and Metrorail systems demonstrate inequalities with regard to the accessibility, affordability, efficiency and reliability experienced by the different students commuting. Both railway lines, however, do not reach the university campus directly and therefore the first/last mile is commuted along regardless of which train system is used. This out-of-vehicle section of the commute is significantly important to the overall experience of the journey and is significantly less researched than in-vehicle experiences. The first/last mile has been receiving global interest in the past two decades, however, there is a gap in literature and knowledge in South Africa on the topic. As the University of Pretoria acts as an urban anchor and Hatfield is envisioned as a student precinct, this section of the journey is extremely important to study in the context of Hatfield.

By investigating hard and soft infrastructural components along the first/last mile between the university's main campus and these two modes of public transport, spatial components in the urban context that hinder and facilitate the first/last mile experience are revealed through the urban sample. Spatial components and factors that hinder the commuting experience include unsafe spaces of movement and a lack of connection to the urban environment. However, spatial components and factors that facilitate the commuting experience are spaces that are mixed-use, have interactive interfaces with boundaries and buildings, safe from vehicle movement, are semi-sheltered and a mixture of hard and soft scaping with shops, services and vendors present for improved passive surveillance. Patterns of interactions discovered between hard and soft infrastructure along the first/last miles revealed that spaces with more factors that facilitate the commuting experience are ultimately more successful and negate spatial injustices as students felt more connected to the surrounding urban context and experienced a more positive commuting experience. Whereas students were more disconnected from the surrounding urban environment, isolated to the movement route and generally had a negative experience in spaces that included more spatial components and factors that hinder the first/last mile commute. These spatial arrangements can be seen as nuances of inequality along the identified first/last mile routes and present opportunities for urban transportation infrastructure development by architects and urban planners.

This layered and holistic understanding through a grounded theory approach and urban sample of how student's commute to places of education can facilitate future urban designs to achieve urban transportation systems and environments that enhance commuters' experience and livelihood and ensure inclusive ease of access to places of education. This is essential in a developing country emerging from past spatial injustices. The study confirms but also builds onto local and international

literature within the urban transport infrastructure and access to education discourse. As existing research is predominantly subjective, this study achieves a holistic understanding by including objective and subjective data on various scales and the theme of land use, which is suggested to be used in future studies as well. Existing transport infrastructure maps and online sites do not demonstrate the subjective experience of the students using it, which also emphasizes the importance of the grounded theory approach method for a holistic understanding.

In conclusion, it is made evident through the urban sample of the study that there are nuances of inequality on various scales experienced by student's commuting to places of education through urban transportation infrastructure in Hatfield. This counteracts the ambition to negate past spatial injustices in South Africa, the vision of Hatfield as a student precinct and the SDG goals and presents opportunities for the development of inclusive commuting routes to the basic right of education.

Future research recommendations to contribute to the urban infrastructure discourse include additional first/last mile routes that may occur over time, first/last mile routes for student's taking different main modes of transport in Hatfield, the interface of university boundary fences and the public urban environment, and first/last mile routes from place of residence to the main mode of public transport. The inclusion of the theme, land use, added value to understanding interaction (or a lack of) between commuters and surrounding environments and therefore is recommended to also be used in future first/last mile studies.

Note: All referencing and intext referencing is completed according to the University of Pretoria's referencing guidelines (Kotze, 2022).

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18.0 Appendices

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

16 March 2023

Reference number: EBIT/32/2023

Miss TA Summerton
Department: Architecture
University of Pretoria
Pretoria
0083

Dear Miss TA Summerton,

FACULTY COMMITTEE FOR RESEARCH ETHICS AND INTEGRITY

Your recent application to the EBIT Research Ethics Committee refers.

Conditional approval is granted.

This means that the research project entitled "Urban infrastructure and inequality" is approved under the strict conditions indicated below. If these conditions are not met, approval is withdrawn automatically.

Conditions for approval:

This approval is conditioned to the UP Survey Committee's approval. Submit the approval from UP Survey Committee once obtained under Docs Due Conditional Approval.

This approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Code of Ethics for Scholarly Activities of the University of Pretoria, or the Policy and Procedures for Responsible Research of the University of Pretoria. These documents are available on the website of the EBIT Ethics Committee.

If action is taken beyond the approved application, approval is withdrawn automatically.

According to the regulations, any relevant problem arising from the study or research methodology as well as any amendments or changes, must be brought to the attention of the EBIT Research Ethics Office.

The Committee must be notified on completion of the project.

The Committee wishes you every success with the research project.

Kai-Yin

Prof K.-Y. Chan
Chair: Faculty Committee for Research Ethics and Integrity
FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

Appendix 1: Ethical clearance approval from the Faculty of Engineering, Built Environment and Information Technology (University of Pretoria, 2023).

Motivation for involving the University of Pretoria's students and personnel

Preface:
As a group we will be conducting semi structured interviews for data collection for the research topic of Urban Infrastructure & Inequality under the supervision of Paul Devenish.
All researchers are students from the Department of Architecture at the University of Pretoria:

Christopher Thompson, 0780103887, u18080295@tuks.co.za

Tayla Summerton, 0736694853, u16027338@tuks.co.za

Taryn Glazebrook, 0826004697, u18130934@tuks.co.za

Thabiso Maja, 0812460101, u17160155@tuks.co.za

(i) What my research is about

Under this research topic I will study how the urban infrastructure of South African cities behaves in relation to social segregation, inequality and public transport, and I will explore ways to transform these conditions. Urban infrastructure includes more than just physical structures like railways and pipes - it also involves social networks and power dynamics. These networks and interfaces function as adaptive systems that control territory and resource flows. Based on this understanding of urban infrastructure, I will use a socio-spatial lens alongside a critical urbanism approach to identify, understand and challenge exclusionary structures. The project aims to identify emergent urban patterns in the contexts of South Africa's urban inequalities and explores alternative methods for architects, urban designers and researchers to analyse urban fabrics. The study will be context driven focussing on public transport gateways and urban interfaces in Hatfield, Tshwane. I will use a range of research methods, including desktop analysis of available research datasets, observation of selected case study sites, drawing and mapping processes, and semi-structured interviews to better understand commuter movement and use patterns. I will compare and assess conditions of segregation, accessibility and exclusion to investigate alternative ways that people are using, occupying and producing urban space on an everyday basis.

(ii) Why UP students or UP personnel from EBIT need to be included

As we are going to be performing the study within Hatfield (a predominantly student populated area), we may interview some University of Pretoria students on their daily commutes to campus. Some interviews may additionally be conducted on the Hatfield campus.

(iii) How data will be collected from them and the duration of the data collection period

The data will be collected from short interviews (+/- 20mins), analysed, and observations will be conducted. The participants may be asked to draw their daily commute and other movements on a map. Data may also be collected in the form of an online survey. The research project duration is from the 24th February 2023 to the 24th July 2023.

(iv) Ask permission to include either UP students, or UP personnel, or both in your study

In accordance with the relevant ethical criteria, may permission be granted to interview University of Pretoria Students.

Appendix 2: Motivation for involving the University of Pretoria's student's and personnel (MProf Research Group, 2023).

Informed Consent Form

(Form for research participant's permission)

(Must be signed by each research participant, and must be kept on record by the researcher)

Preface:
As a group we will be conducting semi structured interviews for data collection for the research topic of Urban Infrastructure & Inequality under the supervision of Paul Devenish.
All researchers are students from the Department of Architecture at the University of Pretoria:

Christopher Thompson, 0780103887, u18080295@tuks.co.za

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Taryn Glazebrook, 0826004697, u18130934@tuks.co.za

Thabiso Maja, 0812460101, u17160155@tuks.co.za

1. Project information

1.1 Title of research project:

Urban Infrastructure and Inequality

1.2 Researcher details:

All researchers are students from the Department of Architecture at the University of Pretoria:

Christopher Thompson, 0780103887, u18080295@tuks.co.za

Tayla Summerton, 0736694853, u16027338@tuks.co.za

Taryn Glazebrook, 0826004697, u18130934@tuks.co.za

Thabiso Maja, 0812460101, u17160155@tuks.co.za

1.3 Research study description.

(i) The project and project objectives

This project aims to understand issues of urban inequality and use of urban spaces adjoining public transport nodes in Hatfield, Tshwane. The exploration of patterns of use of urban infrastructure is aimed at developing new insights and approaches to reduce urban inequalities.

OBJECTIVES

In the context of the public transport infrastructure of Hatfield, Tshwane the project objectives are:

- to understand patterns of use of public transport infrastructure
- to identify issues of inequality
- to identify emergent patterns of use to reframe our understanding

(ii) What will required of participants

The process will undergo a semi-structured interview process where participants will be questioned voluntarily on matters regarding public transportation, movement patterns, activities, accessibility, and associated dynamics. The participants may be asked to draw their daily commute and other movements on a map. Data may also be collected in the form of an online survey

- A short list of question topics will be asked about their commute
  - To where, and from where, they are traveling
  - Frequency of journey

- Alternative ways of traveling
- The safety of transport infrastructure
- Informal networks around formal infrastructures
- Any other issues encountered along the route

- Participants must be over the age of eighteen (18) to participate in this interview.

(iii) The risks to participants

None of the identities and names of the participants will be revealed. Photos may be taken of the surroundings, any persons captured in the photograph will be concealed. No videos or voice recordings will be taken. However, demographic information may be asked such as age, gender, nationality, ethnicity and profession.

- Participants may be required to disclose locational information pertaining to their daily movements and use of public transport. All answers to questions are voluntarily disclosed, however the data gathered will be further analyzed and published as per the University of Pretoria's guidelines.
- This interview will approximately take twenty minutes to complete.
- All data will be collected using Epicollect (a cell-phone application).

2. Informed consent

2.1 I, _____ (Participant Name) hereby voluntarily grant my permission for participation in the project as explained to me by

Christopher Thompson, Tayla Summerton, Taryn Glazebrook, OR Thabiso Maja under the supervision of Paul Devenish.

Master's research group at the Department of Architecture, University of Pretoria (Module DIT 801).

2.2 The nature, objective, possible safety and health implications have been explained to me and I understand them.

2.3 I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the results of the investigation may be used for the purposes of publication.

2.4 Upon signature of this form, the participant will be provided with a copy.

Signed: _____ Date: _____

Witness: _____ Date: _____

Researcher: _____ Date: _____

Appendix 3: Informed Consent Form that was read and signed by research participants before participating in the interviews (MProf Research Group, 2023).

DIT 801: Ethical Clearance Interview Outline

Preface:

As a group we will be conducting semi structured interviews for data collection for the research topic of Urban Infrastructure & Inequality under the supervision of Paul Devenish.

All researchers are students from the Department of Architecture at the University of Pretoria:

Christopher Thompson, 0780103887, u18080295@tuks.co.za

Tayla Summerton, 0736694853, u16027338@tuks.co.za

Taryn Glazebrook, 0826004697, u18130934@tuks.co.za

Thabiso Maja, 0812460101, u17160155@tuks.co.za

Research Topic: Urban Infrastructure and Inequality :

Prior to the interview we will introduce ourselves as students from the university of pretoria conducting research to gain an understanding of how different people use transport daily. Upon consent we will proceed to ask a series of short questions relating to the use of public transport. The answers shall be noted through text on our cell phones.

These are typical question examples we would ask in order to gain insight into the general movement patterns of commuters and the general demographics. Some questions will have a series of options to select from and others will be specific to the individual. The participants may be asked to draw their daily commute and other movements on a map. Data may also be collected in the form of an online survey. This list of questions serves as a guide the interview and will depend on how much time the interviewee has available:

Demographics

1. What is your:
    a. Gender? Female/Male/Other
    b. Age?
    c. Nationality?
    d. Race? Black/White/Coloured/Indian/Asian/Other
    e. Profession/occupation?
2. Do you have any dependents?
3. Do you have any impairments? (if applicable)
4. Do you have difficulties due to impairments? (if applicable)

Patterns of movement

5. What suburb do you live in?
6. Have you experienced any difficulties with using public transport?
7. What do you enjoy about using public transport?
8. To where and from where are you travelling?
9. What is the purpose and frequency of the journey?
10. Which mode of transport do you frequently use?
11. Is this form of transport easily accessible?
12. How long have you been commuting?
13. What other options of travelling are available? (public and private)
14. Why do you choose to use this/these modes of transport?
15. What is your daily estimated transport budget?
16. What do you do when you can't access this mode of transport?
17. What is the duration of your commute?
18. How far do you walk/ cycle (other) along your journey? (0-2km, 2-5km, 5-10km.)

General questions

19. What are the safety concerns and difficulties within your journey?

20. What services/ infrastructure or support facilities could you add to your route to make your experience more comfortable/ convenient?
21. What could make your journey safer?
22. Are there any sanitation issues on the public transport you take?
23. Were there any events that caused you to use public transport/ change the type of public transport?
24. What times do you generally use transport?
25. Why do you use transport at this time?
26. Did working online/remotely during the Covid pandemic relieve transportation related issues?

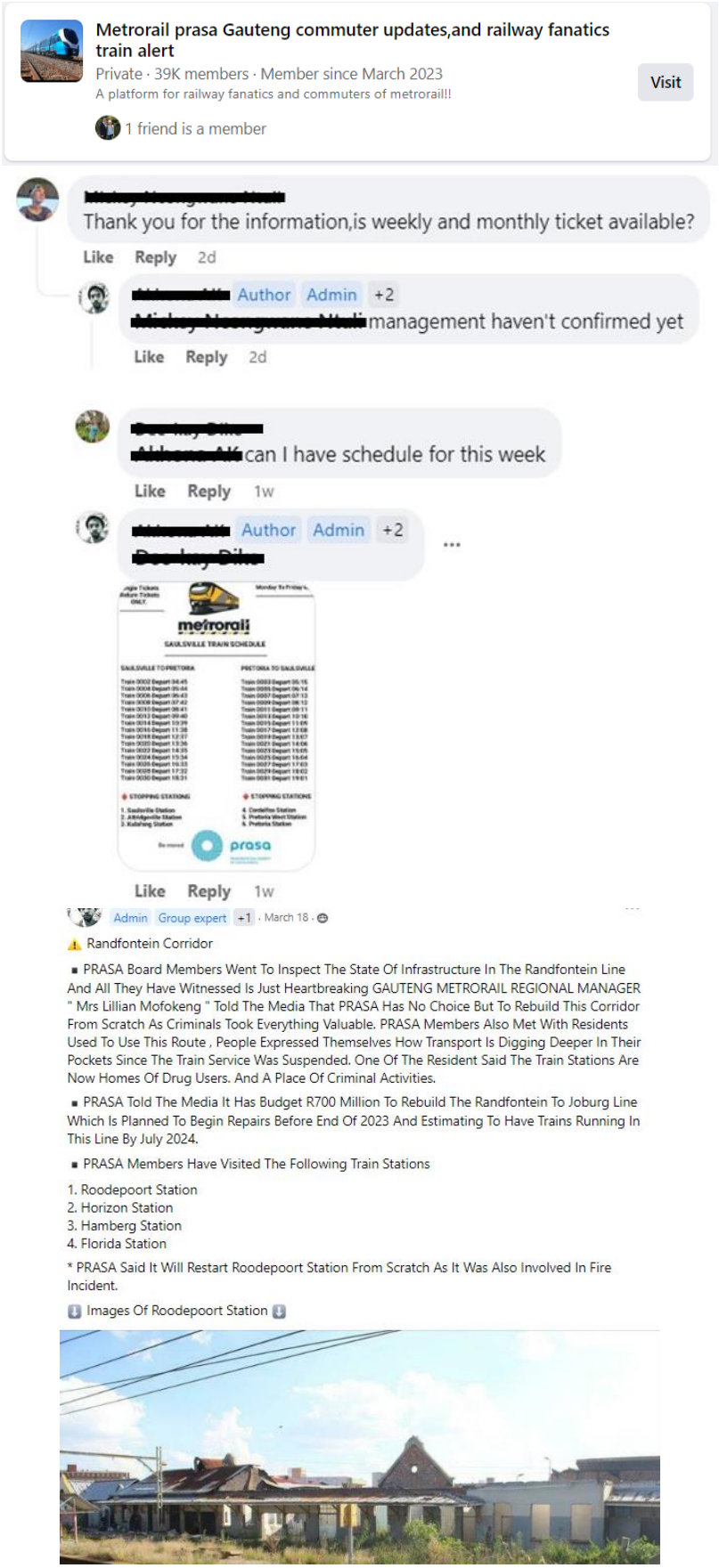
Neighbouring economy

27. Do you purchase at the stationed vendors?
28. What kinds of products do you purchase?
29. When do people buy from you most and what item is it?

Emergent Economy

30. How long have you been operating here?
31. When do you start and how long do you operate for?
32. What did you do before operating here?
33. Where do you source your products?

Appendix 4: Ethical Clearance Interview Outline (MProf Research Group, 2023).



Appendix 5: Messages on the PRASA Metrorail Commuters Facebook group illustrating how the social media platform, Facebook, is used for communicating information about the train system (Facebook, 2023).

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The first/last mile experience of students commuting between the Metrorail and Gautrain stations and the University of Pretoria's main campus in Hatfield.

By
Tayla Ashleigh Summerton
16027338

A Mini–Research Dissertation submitted to the Department of Architecture
at the University of Pretoria
in fulfilment of the module DIT 801
for the degree Master of Architecture (Professional)
24 July 2023

Main supervisor: Paul Devenish
Co-supervisor: Tariq Toffa

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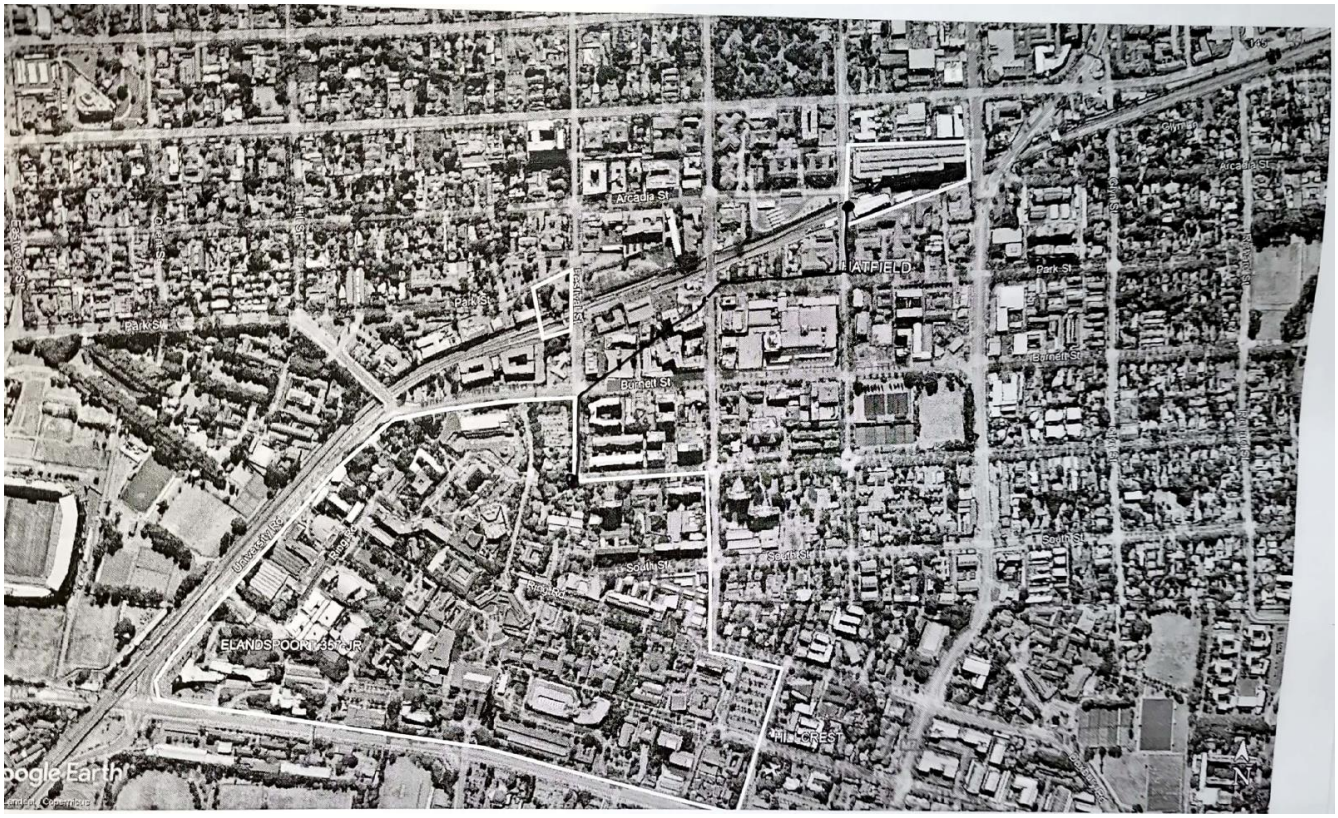
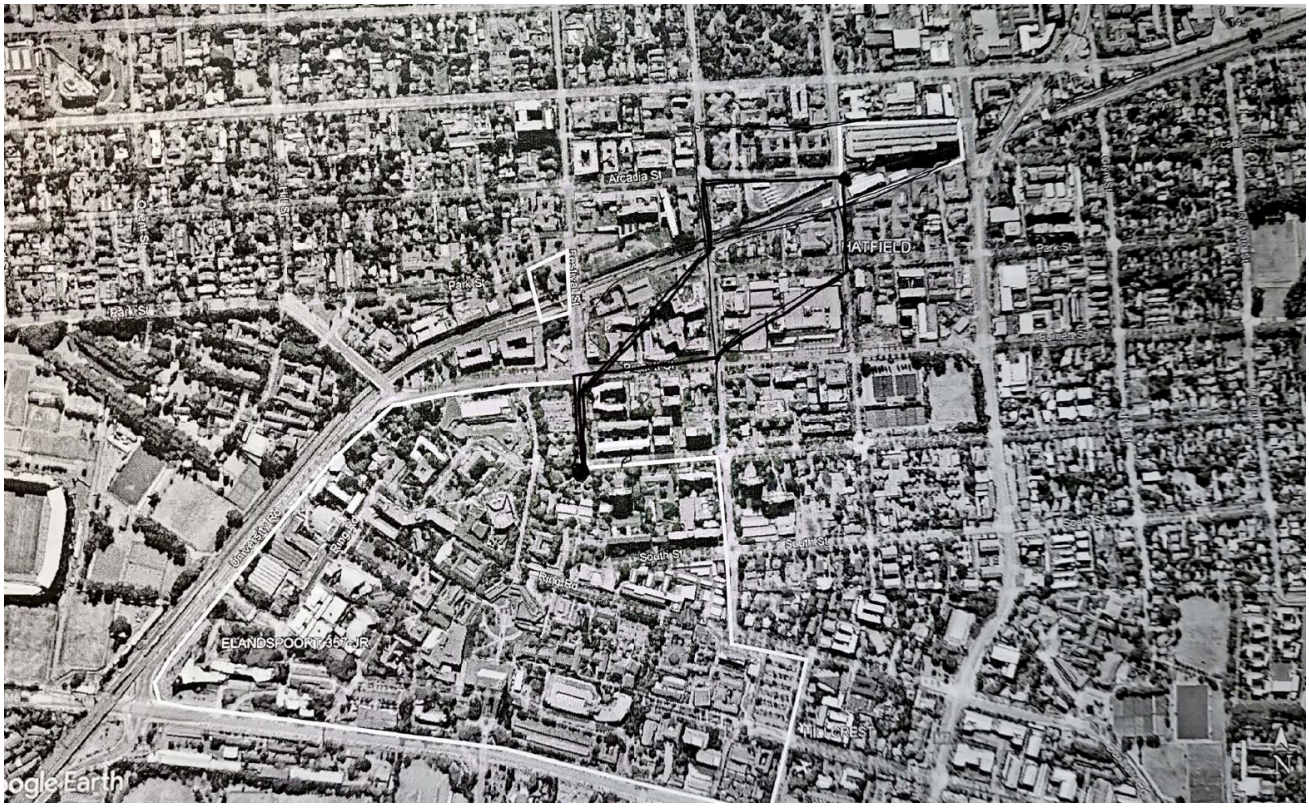
Appendix 6: Plagiarism report receipt (Author, 2023).



Appendix 7: Raw data of common routes through Hatfield indicated by interviewees (Author, 2023). A4 printed map that was drawn on.



Appendix 8: Raw data of common routes through Hatfield indicated by interviewees (Author, 2023). A4 printed map that was drawn on.

Appendix 9: Raw data common routes through Hatfield indicated by interviewees (Author, 2023). A4 printed map that was drawn on.

Interviewee	Date:	Time:	Data capture tool:	Gender	Age:	Occupation:	Race:	What suburb do you live in?	To where, and from where are you travelling?	What is the frequency of your journey?	What time do you generally use the public transport?	Do you purchase anything from the surrounding vendors? If so, what?
1.	17/03/23	2:05:41 PM	Survey Monkey	Male	23-29	Student	White	Weltevreden Park	Roodepoort to Hatfield and return.	2/3 times a week	9am - 11am, 12pm - 2pm, 3pm - 5pm	No
2.	17/03/23	2:20:51 PM	Survey Monkey	Female	18-22	Student	Black	Pretoria	Lotus gardens to Hatfield	Monthly	5am - 8am, 9am - 11am, 3pm - 5pm,	Yes, informal, Snacks
3.	17/03/23	2:22:30 PM	Survey Monkey	Female	23-29	Student	Black	Garsfontein	Garsfontein-Hatfield	Daily	9am - 11am, 3pm - 5pm	No
4.	17/03/23	3:06:23 PM	Survey Monkey	Male	18-22	Student	White	Randburg	Hatfield from Randburg	Daily	5am - 8am, 6pm+	No
5.	17/03/23	4:12:24 PM	Survey Monkey	Male	18-22	Student	White	Noordhang	Home to the university of pretoria	Daily	5am - 8am, 9am - 11am, 12pm - 2pm, 3pm - 5pm,	No
6.	17/03/23	5:50:31 PM	Survey Monkey	Male	23-29	Student	Black	Edenvale (staying in Pretoria CBD)	Hatfield to Pretoria CBD	2/3 times a week	12pm - 2pm, 3pm - 5pm	Yes, informal, snacks
7.	17/03/23	5:57:19 PM	Survey Monkey	Male	18-22	Student	Indian	Edenvale	Edenvale Johannesburg to Hatfield Pretoria	Daily	5am - 8am, 9am - 11am, 12pm - 2pm, 3pm - 5pm,	No
8.	18/03/23	11:32:30 PM	Survey Monkey	Male	23-29	Student	White	Lynwood	From my home, to the University of Pretoria's Campus	Daily	5am - 8am, 9am - 11am, 3pm - 5pm	Yes, formal, Fresh produce
9.	27/03/23	5:22:44 PM	Survey Monkey	Male	18-22	Student	White	Craighall Park	To Hatfield from Rosebank	2/3 times a week	5am - 8am, 3pm - 5pm	No
10.	27/03/23	8:10:03 PM	Survey Monkey	Male	18-22	Student	Black	Booysens	I travel from Booysens which is on the far northwest side of Pretoria to Hatfield, UP.	Daily	5am - 8am, 3pm - 5pm,	Yes, informal, snacks
11.	27/03/23	12:24:11 AM	Survey Monkey	Female	23-29	Student	Black	Pretoria	Pretoria to Hatfield	Daily	5am - 8am, 3pm - 5pm	-

Interviewee	Mode of transport frequently used?	Is this form of transport easily accessible?	Do you have any difficulties using public transport and if so, what?	How long have you been commuting/ using public transport?	Are there any other options available to you for travelling this route?	Why do you choose this mode of transport?	What is your daily estimated transport budget?	Duration of trip to get to destination?	How far do you walk/cycle along your journey?	What would you add to make your trip more convenient/comfortable?	Do you wait anywhere along your journey? If so for how long and what is the experience like?	Do you use multiple forms of public transport along your journey? If so, what kinds? (walk, cycle, bus, train, etc.)
1.	Train (Metrorail)	Yes	No. Crowds can be inconvenient, but I have never had any trouble.	1 year +	Yes. Driving.	Cheaper than driving and inaccessibility of my own transport.	R41.00-R90.00	31-60mins	2.1-5km	-	Yes, occasionally. Depending on the security of the area, it can be a little stressful.	Walking, Train.
2.	Bus	Yes	No	1 year +	No	Easiest and cheaper	R21.00-R40.00	31-60mins	0-1km	Shade	Wait for at least 15 -30 minutes and it's exhausting	Walk
3.	Bus	Fairly	No	less than 6 months	Yes	Punctuality	R41.00-R90.00	16-30mins	1.1-2km	More stops	Risky. 10-20mins	-
4.	Train (Gautrain)	Yes	-	1 year +	Yes. A car	Cheaper and more reliable	R91.00 +	31-60mins	1.1-2km	Aircon	No	Walk
5.	Train (Gautrain)	Yes	-	1 year +	I could drive my own vehicle	Reduces wear and tear on my vehicle and gives me freedom to do work while commuting	R91.00 +	61mins +	2.1-5km	Further expansion of the Gautrain rail line to my area, as currently I either need to drive, get a lift or catch the bus from monte casino	No	I walk from the Hatfield station to the University
6.	Train (Metrorail)	Yes	-	less than 6 months	Yes; Uber, Taxi, and Bold.	It's affordable, R11 per trip.	R11.00-R20.00, R41.00-R90.00	16-30mins	0-1km	Track the transportation position	Weight at station	Walking
7.	Train (Gautrain)	Yes	-	1 year +	Yes, Private vehicle however to much wear and tear	Easy, Next most convenient option to private vehicle	R91.00 +	31-60mins	1.1-2km	Use the bus from the station to campus	When i transfer trains, 3-9 mins, pretty chilled	Train, then bus or walk
8.	Walking/ cycling	Yes, I am fortunate enough to own a bicycle and I think it's one of the most wonderful forms of transport.	When cycling, however there's quite a few dips and bad pieces of paving- so it's not suitable for all bicycles. When cycling in the road, cars and busses often pass very close to you as road is quite narrow	10 years +	Yes, I can use a car or take the bus, there are bus stops near me. I have considered using them.	I can come and go on my own time, the costs are minimal and it's environmentally friendly. And faster than cars and busses in traffic-really.	R0.00-R10.00	0-15mins	2.1-5km	A cycling lane/ just a wider tarred shoulder. The sidewalk is for pedestrians. And people go both ways on one side of the street, so often don't see you coming.	Yes, but not often and not long. Sometimes the cars there that drives fast makes it difficult to get through.	-
9.	Gautrain	Yes	No	1 year +	No	Affordable	R41.00-R90.00	31-60mins	1.1-2km	Closer train stop	I wait at the train stations, normally wait for a few minutes,	Train and walking
10.	Bus	Moderately.	I cannot work after hours in school because the last bus is at 6pm. I also have difficulties carrying school projects such as maquettes and models because the bus is constantly full with limited space for parcels.	1 year +	I could use a taxi, but it poses the same problems and is more expensive than the bus. I also could walk but it would be a three hour walk which is not is not conducive to good time-management.	It is the cheapest reliable option I have.	R21.00-R40.00, R41.00-R90.00	31-60mins	10.1km +	I would add an option to get space for putting my maquettes.	Stations. The waiting is usually time-consuming.	Walk
11.	Train (Metrorail)	Yes	-	1 year +	walk	Its affordable	R21.00-R40.00	0-15mins	2.1-5km	Increase number of stops during peak hours so people don't have to wait so long	I have to wait at the station During peak hours, it can be very uncomfortable because of the lack of seating.	Yes. I walk to the station, and I take the train to the next station that's nearest to my destination, then I walk the rest of the way until I arrive at my destination.

Interviewee	Date:	Time:	Data capture tool:	Gender	Age:	Occupation:	Race:	Why do you take this route? Are there any alternative routes that you take?	Do you take the bus feeder route at all? Why or why not?	Do you experience any difficulties using the train or along this route?	Do you wait anywhere along this route? Where?	What would you add to make your trip more convenient/ comfortable?
12.	15/05/23	06:47 AM	EpiCollect	Male	18-22	Student	Black	Shortest and most convenient	When it rains	-	No	Lighting along route
13.	15/05/23	06:57 AM	EpiCollect	Female	18-22	Student	Black	Safest	Raining only	Use certain route to avoid beggars, cut through The Fields because it is pedestrian friendly and feels like a student environment. Use quieter roads as they are safer from traffic	No	More lighting, safety from traffic
14.	15/05/23	07:05 AM	EpiCollect	Female	18-22	Student	Black	Safest & shortest	When raining	Lighting and traffic during loadshedding	No	More pedestrian crossings & safety from traffic
15. (Group interview)	15/05/23	07:30 AM	EpiCollect	Female	18-22	Student	Indian	Quickest, safest, you can buy items from Hatfield plaza, don't buy from informal vendors, shading & greenery	No, you need to pay	Unsafe areas along other routes. Beggars along Burnett street.	No	Cover, wider walkways, road crossings, more safety personnel, sufficient lighting
16. (Group interview)	15/05/23	07:30 AM	EpiCollect	Female	18-22	Student	White	Quickest, safest, you can buy items from Hatfield plaza, don't buy from informal vendors, shading & greenery	No, you need to pay	Unsafe areas along other routes. Beggars along Burnett street.	No	Cover, wider walkways, road crossings, more safety personnel, sufficient lighting
17. (Group interview)	15/05/23	07:30 AM	EpiCollect	Male	18-22	Student	Black	Quickest, safest, you can buy items from Hatfield plaza, don't buy from informal vendors, shading & greenery	No, you need to pay	Unsafe areas along other routes. Beggars along Burnett street.	No	Cover, wider walkways, road crossings, more safety personnel, sufficient lighting
18. (Group interview)	15/05/23	07:30 AM	EpiCollect	Male	18-22	Student	Indian	Quickest, safest, you can buy items from Hatfield plaza, don't buy from informal vendors, shading & greenery	No, you need to pay	Unsafe areas along other routes. Beggars along Burnett street.	No	Cover, wider walkways, road crossings, more safety personnel, sufficient lighting
19.	15/05/23	07:40 AM	EpiCollect	Male	35-64	Lecturer	White	Quickest, depending on how user feels	When it rains	Some paths are noisy and unpleasant, areas/roads difficult to cross	No, sometimes at the field's café and seating though	-

Interviewee	Train type	Do you feel safe along this route? Is there sufficient lighting?	What do you do when it rains?	Duration of trip to get to destination?	What time do you generally use the public transport?	What is the quality of the sidewalks?	Do you feel protected from traffic along this route?	In general, what is your experience of this route? Do you feel that it is connected or disconnected from surrounding buildings?
12.	Gautrain	No, there is not enough lighting in certain areas along route	Take bus	0 – 15 mins	5am - 8am, 3pm - 5pm	Generally good	No, there are no crossings at some places	Don't feel connected to surrounding environment
13.	Gautrain	No, there are beggars and security guards	Bus	0 – 15 mins	5am - 8am, 3pm - 5pm	The sidewalks needs maintenance. There are obstructions and broken paving	No	In some areas connected to surrounding buildings like The Fields
14.	Gautrain	Sometimes, there are beggars on Burnett street	Bus	0 – 15 mins	5am - 8am, 3pm - 5pm	In areas there is no space to walk and obstructions in the way, and it is uncomfortable	Not during load shedding, cars park on pavements and obstruct the walkway	Disconnected, there are fences that line the walkways
15. (Group interview)	Gautrain	Sometimes, there is no lighting down Gautrain road at night	Walk	0 – 15 mins	5am - 8am, 3pm - 5pm 9am – 11am	Good, nice trees for shading, sometimes litter	Not while crossing roads especially during load shedding	Disconnected, only use path as movement to university, don't socialize or hang around
16. (Group interview)	Gautrain	Sometimes, there is no lighting down Gautrain road at night	Walk	0 – 15 mins	5am - 8am, 3pm - 5pm 9am – 11am	Good, nice trees for shading, sometimes litter	Not while crossing roads especially during load shedding	Disconnected, only use path as movement to university, don't socialize or hang around
17. (Group interview)	Gautrain	Sometimes, there is no lighting down Gautrain road at night	Walk	0 – 15 mins	5am - 8am, 3pm - 5pm 9am – 11am	Good, nice trees for shading, sometimes litter	Not while crossing roads especially during load shedding	Disconnected, only use path as movement to university, don't socialize or hang around
18. (Group interview)	Gautrain	Sometimes, there is no lighting down Gautrain road at night	Walk	0 – 15 mins	5am - 8am, 3pm - 5pm 9am – 11am	Good, nice trees for shading, sometimes litter	Not while crossing roads especially during load shedding	Disconnected, only use path as movement to university, don't socialize or hang around
19.	Gautrain	Yes, may be bias	Walk through plaza, or bus	0 – 15 mins	5am - 8am, 6pm+	Good, that's why I use these routes	Mostly	Connected to buildings you can walk through

Appendix 10: Tabulated student interviews through Epicollect and Survey Monkey (Author, 2023). This raw data informed the urban sample in section 14.0.

	Time:	Location:	Activities executed:	Data collection method:	Observations:	Conclusions/findings:	What to do next:
Stage 1 **08/03/23**	Site visit: Approx. 1pm – 4pm (approx. 3 hours)	Hatfield - Rissik station - Loftus station - Hatfield CBD - Gautrain station - bus & taxi stops	Available desktop data consulted Observational walk around Hatfield, looking at public transport infrastructure Discussions of observations with research group	Desktop analysis (maps) Visual observations & photographic observations	Certain routes were being used by students commuting to the university from public transport stops (specifically the train stops as an influx of students exited the trains at intervals) Metrorail (Rissik & Loftus) and Gautrain systems are popularly used by students Informal traders set up around paths of movement (especially where there are students commuting) Main public modes of transport do not reach final destinations and therefore commuters usually walk to final destinations Little support for cyclists in Hatfield Most land uses are isolated from movement paths by fences The Gautrain contains readily available information about the system There are different types of people using the different public transport systems (Gautrain vs. Metrorail)	The desktop data available consisted of quantitative data (maps) only. There was a lack of qualitative data about transport infrastructure in Hatfield There are specific routes taken by commuters from main modes of transport to final destinations. Are there specific routes taken by students? Why do they take these routes? Does transport infrastructure affect the commute? Topic of interest = students regarding transport infrastructure The train systems in Hatfield appear to be major transport modes for people, especially students.	Review literature on: - students commuting to university in South Africa/Hatfield regarding transport infrastructure - transport infrastructure factors affecting students' commute - methodology Interview students to gain an understanding of: - which public transport types they use - why they use this type of transport network - the journey to university Focus on Metrorail & Gautrain systems Research desktop data on: - how the train networks connect to the larger context - Information about train networks (prices, stops, stop intervals)

	Time:	Location:	Activities performed:	Data collection method:	Observations:	Conclusions/findings:	What to do next:
Stage 2 **22/03/23**	Site Visit: 07:30 AM – 4:30 PM (approx. 9 hours)	Metrorail train system (Rissik station) Metrorail train system (Loftus station)	The urban infrastructure research group experienced public transport infrastructure by commuting to Pretoria CBD via the Metrorail train system from Rissik station to Pretoria station, and then back to Hatfield via a taxi Interviewing commuters and informal traders with the research group Observed students exiting the Metrorail train station during peak hours and identifying which routes to campus are predominantly taken Observing how these students commute along these routes and how they interact with the immediate context Desktop analysis of maps, urban frameworks, train system websites and literature review is ongoing at this point	Visual observations & photographic observations of different times of the day Interviews (Epicollect) Experiencing the Metrorail train system during peak hours (7am) Online student surveys (via survey monkey) sent out on 17/03/23 to student WhatsApp groups	Metrorail Rissik station: - peak hours are from 5am – 8am, and 3pm – 5pm - crowding during peak hours. Not enough seating - Metrorail ticket machines not operational - Long waiting periods for trains. Uncomfortable wait - no ticket/train information available Loftus station: - predominantly used by students - no ticket/train information available - Informal activities occur around movement routes (especially student movement routes). i.e., informal vendor & socializing There are specific routes taken by students to walk between campus and the stations The predominant time of a student commuting is 31-60mins The predominant distance walked from a station to the university is between 1km-5km The daily estimated budget for Gautrain commuters is significantly higher than Metrorail commuters Students commuting on the Gautrain to get to campus predominantly had a private vehicle that they could use as an alternative option. Whereas students using the Metrorail didn't. Whichever train system the student used was the most accessible option available to them. (in terms of proximity, cost, reliability) Other forms of public transport are more expensive, that is why the train systems are used	At this point in time, the "first/last mile" was identified and being reviewed through literature From visual observations, the predominant first/last mile from the Metrorail Loftus station to the university of Pretoria pedestrian gate was concluded. (Figure 11) Reason - It is the shortest route. From visual observations, the predominant first/last mile from the Metrorail Rissik station to the university of Pretoria pedestrian gate was concluded. (Figure 14) It is the shortest route. It was apparent that there are significant differences between the Gautrain and Metrorail train systems in terms of accessibility, reliability, prices and operation. It was evident that commuters use multiple forms of commuting when traveling to and from their place of residence to a destination. This predominantly included walking, a main mode of transport, and then walking again. Students indicated that the following aspects would create a more comfortable commute: - Track the transportation position - increase number of train stops during peak hours - shading Difficulties students experienced along the commute: - crowds at the Metrorail stations during peak hours - uneven pavements	Conduct more research around students using Gautrain and specific routes used Conduct more interviews to ground visual observations Examine identified first/last mile routes through photographs in terms of spatial components identified in literature review

	Time:	Location:	Activities performed:	Data collection method:	Observations:	Conclusions/findings:	What to do next:
Stage 3 27/03/23	Site Visit: Approx. 1:00pm – 4:00pm (approx. 3 hours)	Metrorail first/last mile routes between the stations and the university In and around the Gautrain station in Hatfield	Visual observations & photographic observations of students commuting to and from the Gautrain station and the campus. As well as how they interact with the immediate context Student online surveys on 22/03/23 via Survey Monkey.	Visual & photographic observations Scanning through social media platforms of Metrorail groups Online surveys	Students take the Gautrain feeder bus only when it rains. Students using the Metrorail systems use umbrellas There are security personnel in and around the Gautrain station which gives a sense of safety Information is accessible in and around the Gautrain system There are no informal vendors/stores along pedestrian movement routes near the Gautrain station (the surrounding spaces are more sterile and hostile) Through desktop mapping it is evident that the Gautrain system connects wealthier economic areas such as Rosebank and OR Tambo airport. It was observed that the students using this transport system were also from a wealthier economic background when compared to the commuters on the Metrorail system. The predominant first/last mile routes used were the shortest, safest and most convenient route available. Along some areas of the routes there is a lack of protection from traffic and vehicles causing students to not feel safe Trees providing shade create a more pleasant experience It is evident that Metrorail users communicate on a Facebook Metrorail group about ticket prices, train delays, maintenance, etc.	The predominant first/last mile route between the Gautrain and campus is not concluded as there are multiple routes a commuting student can take. Conducting interviews online as surveys deemed more successful as students could answer the questions in their own time, instead of being rushed while commuting to or from lectures on campus. The lack of access to communication and information of the Metrorail system hinders the ease of use	Print maps and ask students to indicate on the map which routes they predominantly use to commute to the campus and why. (Gautrain) Observe how students interact with the context and spatial components of the identified route/s Analyze data collected at this stage through first/last mile table identified in literature to form urban sample. Identify whether these components hinder or facilitate the commute

	Time:	Location:	Activities performed:	Data collection method:	Observations:	Conclusions/findings:	What to do next:
Stage 4 15/05/23	Site Visit: 06:00am – 10:00am (approx. 4 hours)	Gautrain station and identified predominant first/last mile routes	Interviewing students and asking them to draw on a map the predominant route walked from the Gautrain station to the university campus Visually and photographically observing how students interact with the context along the predominant identified route	Epicollect for interview answers, printed A4 maps for drawing predominant routes used on and mobile device for photographs	A predominant first/last mile route was taken from the Gautrain station to the university campus due to several factors such as: - safety from traffic - unsafe spaces (lack of lighting in areas) - The bus feeder route is only used when it is raining - areas of the sidewalk can be improved upon The route cuts through The Fields because it is pedestrian friendly, has passive surveillance and interactive building interfaces Burnett street is avoided due to beggars and car guards that make it feel unsafe. There is also litter and cars parked along sidewalks The predominant first/last mile route is altered slighting when it rains as students pass through the plaza. This also offers an opportunity to buy products on the way home/to campus The areas surrounding the Gautrain station are much more sterile and hostile than those of the Metrorail stations	The predominant first/last mile route is identified (as seen in figure 21). There are several spatial components identified in literature that hinder or facilitate the commute between the Gautrain station and the university campus. To be elaborated on in urban sample. Spatial components identified in literature evidently affect the commute along first/last mile routes. This is evident in the data collected from interviews, online surveys and visual observations.	Analyze photographs taken along predominant first/last mile routes in terms of the spatial components identified in literature and conclude findings Suggest how the study can be expanded on in future research - routes are adaptive according to what is happening in surrounding environment - first/last mile routes from other main transport modes to the university campus

Appendix 11: Tabulated process of collecting and analysing data and forming conclusions that informed the urban sample in section 14.0 (Author, 2023).