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Factors Affecting Multimodality in Groningen Among Student Population

Figure 1. A bus stop at Groningen Central Station

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Bachelor Thesis
University of Groningen
June 2024

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Abstract

This thesis aims to explore the factors influencing the use of multimodal transportation among the student population in Groningen. Through qualitative research involving semi-structured interviews with Bachelor students from the University of Groningen, key determinants such as socio-demographic characteristics, built environment, transport systems, policies, and weather conditions were examined. The findings reveal a strong preference for cycling, supported by Groningen's extensive bicycle infrastructure, while public transport is utilized for longer distances and in adverse weather conditions. Policy implications suggest that soft policies like social marketing can promote sustainable transport choices through peer influence, while hard policies should focus on improving public transport infrastructure and integration. The study's insights aim to support the development of sustainable and efficient multimodal transportation systems in urban environments. Future research should address the limitations of this study by including larger and more diverse samples, and investigating the long-term effects of infrastructure improvements.

1. Introduction

1.1 Background

With the rising urban population and the grand urbanization process, the demand for mobility rapidly increases, inducing challenges such as air pollution, congestion, and high energy dependency. In such an environment, better integration of existing infrastructure is essential for developing sustainable transportation systems (Shah et al., 2021).

Passenger multimodal transportation could be one of the key strategies to solve the growing demand for mobility in expanding urban areas. According to Liao et al., 2020 *"Multimodality is the use of more than one transport mode during a trip or a specific period in a broad sense."* It has been considered to improve the accessibility of locations, reduce fossil fuel-based car dependency, and accomplish a fundamental shift to environmentally friendly modes (Klinger, 2017).

Since the late twentieth century, multimodal transport-oriented planning has been practiced in European countries (Huang, Ma and Jonas De Vos, 2024). However, only in 2007, did Nobis (2007) present a research paper exploring the characteristics of multimodal travel behaviour and its influencing factors. Since then, a growing amount of research has been focused on the exploration of multimodal travel behaviour. Nonetheless, theories and definitions concerning multimodal transportation lack consistency and research norms (Huang, Ma and Jonas De Vos, 2024). Moreover, implementing multimodal transport services is highly dependent on the context of different urban environments and mobility cultures. According to Klinger (2017), tendencies toward multimodality vary by overall mobility culture in a particular city, which is expressed, for example by its car dependency or bicycle-friendliness. One of the central findings of his study suggests that people who moved to public transport or cycling-friendly cities are more likely to become multimodal than the ones who moved to auto-oriented cities in Germany (Klinger, 2017). This highlights the importance of enriching already existing research on this topic.

In the context of the city of Groningen, little research has been done on the closely related topic of the multimodality of students. Rongen, T, Tillema, T & Arts, J (2020) performed a qualitative literature analysis of the multimodal hub concept in Dutch national transport and land-use policy. Schaffsma (2021) wrote his master's thesis on intermodal commuting via multimodal hubs in Groningen. However, there has not been any research focusing on multimodal transportation choices of students in Groningen. While multimodal transportation and the factors affecting it have been extensively studied, several factors received comparatively less attention in research. These include, but are not limited to; user experience when transitioning between modes, including factors such as the ease of transferring between modes, the consistency of information provided across modes, and the overall comfort and convenience of the journey (Rodrigues et al., 2021). Furthermore, there's a need for more research into how different socioeconomic groups

access and experience multimodal transportation (Nakshi, 2020), especially low-income individuals, the elderly, and people with disabilities. Research on young adults and students is limited; Nash and Mitra (2019) explored socio-demographic, attitudinal, and environmental factors that influence day-to-day trips by young adults in Toronto; however, the findings should be interpreted with caution due to limitations in data, context, and methodology. In line with this, the fact that the research was solely focused on the travel behaviour of university students in North America, makes the findings nonrepresentative of students in other parts of the world.

Therefore, this study aims to fill a research gap in exploring factors affecting the use of multimodal transportation among the student population of Groningen. Studying factors influencing the usage of multimodal transportation is essential to better understand the urban mobility system in Groningen and potential ways for it to improve and become more efficient. Furthermore, understanding students' multimodal behaviour can help to promote more sustainable transportation choices and identify barriers to adopting those, whilst also designing interventions to overcome them.

1.2 Research Problem

This study aims to explore factors affecting the use of the multimodal transport system among the student population of Groningen. The influence of socio-demographic characteristics, built and social environments, and transport systems and policies on the use of multimodal transportation will be explored. Subsequently, the following main research questions and secondary questions were developed.

1.2.1 Research Question

What factors affect the use of multimodal transport systems among students in Groningen?

1.2.2 Secondary Questions

To what extent and how does the built environment affect the usage of multimodal transport among students in Groningen?

To what extent and how do transport services affect the usage of multimodal transport among students in Groningen?

To what extent and how do sociodemographics and attitudes affect the usage of multimodal transport among students in Groningen?

To what extent and how do social environments affect the usage of multimodal transport among students in Groningen?

1.3 Structure of Thesis

Firstly, Section 2 provides a theoretical framework drawn from numerous studies on multimodal transportation, including the conceptualisation of multimodality and its measures, and factors affecting multimodal transportation uses. Then, based on the theoretical framework, conceptual models and expectations are outlined. In Section 3, the methodology is discussed with a focus on semi-structured interviews, ethical considerations, and limitations of the data collection method. In Section 4 results of the analysis of primary qualitative data are discussed in detail. The discussion is divided into 4 main topics, based on existing scientific knowledge about the distinction of factors that influence multimodal travel. Lastly, in Sections 5 and 6 conclusions and recommendations for further research are mentioned.

2. Theoretical Framework

The theoretical framework will discuss the overall context of the research and explore the factors that affect the use of multimodal transport systems in the already existing literature.

2.1.1 Conceptualizing Multimodality

Currently, the research has identified two main categories of multimodality, being *individual-level multimodality* and *trip-based multimodality.* The first is defined by individuals using various transport modes in their daily routines (Heinen & Chatterjee, 2015). The other one is defined by using various transport modes within a single journey (Huang, Ma and Jonas De Vos, 2024). Nobis (2007) emphasized that a general definition of multimodality must entail a time frame, possibly a week, for not only exploring end-to-end trips but also the specific patterns of travelling. Furthermore, opposing two categories of multimodality, the researchers incorporate monomodality (Huang, Ma and Jonas De Vos, 2024), defined as using one mode form of transport during a trip, day, week, month, etc.

2.1.2 Measures of Multimodality

Studies related to multimodality typically analyze travel behaviour by examining the mode choices of travellers over a certain period or the combination of modes within a single trip (Huang, Ma and Jonas De Vos, 2024). Typically, data analysis relies on large-scale national surveys. For example, Heinen & Chatterjee (2015) used National Travel Survey data for Great Britain to research the prevalence of multimodal travel; the study showed that the majority of the population of Great Britain - 69% are multimodal over their weekly travel. Generally, multimodal prevalence rates increase as the observation period is extended (Huang, Ma and Jonas De Vos, 2024).

Since the definition of multimodality is broad, depending on the research question researchers specify (i) the observation period (ii) the number of transport modes considered, or (iii) thresholds for frequencies of modes being used (Groth, 2019). The observation period can vary from several weeks to even one day. To accurately estimate the prevalence of multimodal travel; a threshold for the frequency and intensity of mode has to be established. This refers to the minimum level of use that defines whether an individual is considered a user of a particular transport mode or a multimodal traveller. Occasionally, some residents might use different travel modes without necessarily having a strong preference for multimodal travel, making it necessary to qualify multimodal trips using secondary travel modes' frequency or intensity (Huang, Ma and Jonas De Vos, 2024). For instance, Nobis (2007) defines multimodal trips as those where any one mode accounts for between 30% and 70% of total trips. If a traveller uses one mode for more than 70% of their trips, they are considered a single-mode user rather than a multimodal traveller.

At the individual level, researchers have used continuous quantitative indicators to measure individuals' degree of multimodality (Heinen & Chatterjee, 2015; Diana & Pirra, 2016; Huang, Ma and Jonas De Vos, 2024), such as Gini index, Dalton index, and Herfindahl- Hirschman index (HHI) coming from the field of economics but applied in transport research. For example, Heinen & Chatterje, (2015) used HHI to assess the level of multimodality, where an index of close to or equal to 0 indicated preference for multimodality, whereas an index of close to or equal to 1 indicated preference for a single mode. However, the choice of method for measuring multimodality should be considered case by case Diana & Pirra (2016).

By understanding and recognizing groups with different multimodality patterns, urban planners and policymakers could better tailor policy designs to enhance the usage of multimodal transport systems (Huang, Ma and Jonas De Vos, 2024).

2.2 Factors Affecting Multimodal Transport Uses

2.2.1 Mode Choice of Student Population

There has been substantial scientific research done exploring transportation mode choices among student populations around the world (Moniruzzaman & Farber, 2018; Wang & Liu, 2015; Lavery et al., 2013). That being said, researchers have found that modality is heavily influenced by a combination of demographic, attitudinal, and spatial/land use variables. Concerning mode of travel, active travellers tend to have a higher multimodality compared to users of motorized modes (Lavery et al., 2013).

Regarding the population of Groningen, Hermes (2022) explored factors influencing the choice of transport mode among students. Students' mode of transport choice when travelling to the university (sample of N=223) is displayed as follows; 14.3% walking, 71.3% cycling, 13% public transport, 0.9% driving, 0.4% other. Thus, making cycling a preferred and most frequently used mode of transportation among students in Groningen as of 2022. Due to cycling being a preferred mode of transportation of students in Groningen, one can say that Groningen is to an extent a monomodal city.

2.2.2 Built Environment

Two different types of research are presented in the literature review of built environment factors - some literature is directly linked to multimodality (Lee, 2023; Ardeshiri & Vij, 2019) while other is linked to general research about mode choice (Suzuki, Cervero and Iuchi, 2013).

According to Lee (2022), built environment characteristics were found to be statistically significant predictors of multimodality across the United States. Furthermore, the study has identified certain features having considerable importance, including population density, regional accessibility, walkability index, and network density. Other factors enhancing multimodal travel behaviour include; high land use mix, accessibility to public transport services and bicycle infrastructure (Ardeshiri & Vij, 2019).

Furthermore, the design of the built environment was found to be an influential factor in the choice of transportation. According to Suzuki, Cervero and Iuchi (2013) improving the quality of pedestrian areas, biking paths and places near transit stations will make it more attractive for people to use sustainable modes of transport rather than motorized vehicles.

2.2.3 Transport System and Policies

With incentives and restrictive policies, cities can create favourable conditions for multimodal transportation (Huang, Ma and Jonas De Vos, 2024). Incentive policies are formal policies used to promote a specific behaviour or action for a specific group of people for a defined period. An example of an incentive transportation policy in the Netherlands includes the implementation of cycling infrastructure and the promotion of cycling as a preferred mode of transportation. Incentive programs tend to work best in promoting sustainable multimodal travel options (Kandolah, 2018). On the other hand, restrictive programs such as reducing car spaces have been shown to encourage more multimodal trips among car users (Huang, Ma and Jonas De Vos, 2024). Examples of restrictive transportation policies in the Netherlands include the implementation of low-emission zones (LEZs) in certain cities e.g. Amsterdam to regulate and reduce air pollution caused by vehicles. LEZs are areas where access by high-polluting vehicles, typically those with older diesel engines, is restricted or subject to additional fees or penalties.

Furthermore, a well-designed multimodal transport system facilitates intermodal transfers and connections. The performance of alternative transport modes is an important factor in achieving modality shift. Besides, transport service factors such as frequency of service, safety, and competitiveness of travel times have a further positive impact on transition. Reliability and ease of transfer play a crucial role in trip-level behaviour (Huang, Ma and Jonas De Vos, 2024). Lastly, the provision of accurate information about transport services is crucial because it assists travellers in planning their journey, simplifying the modal shift.

2.2.4 Socio-Demographic

Socioeconomic status significantly influences multimodal travel behaviour. Usually, individuals with higher socio-economic status tend to be monomodal, implying the usage of private vehicles on daily trips. In contrast, low-income individuals without access to private vehicles are more likely to engage with and use multimodal transportation (Huang, Ma and Jonas De Vos, 2024). Furthermore, gender and age play a significant role in the choice of transportation modes. According to Heinen & Chatterjee (2015), females typically exhibit higher levels of multimodality due to their complex activity patterns and family responsibilities. On the other hand, males tend to have more homogenous travel patterns, as they are more focused on work-related travel. Furthermore, since age is related to different stages of life, it leads to different travel perceptions. For example, younger generations born in the 1990s and 2000s are more inclined towards reducing private car usage and opting for modal shifts (Huang, Ma and Jonas De Vos, 2024).

Individual factors such as attitudes and social norms influence multimodality. Positive attitudes towards green modes and environmentally friendly travel promote multimodal behaviour (Huang, Ma and Jonas De Vos, 2024). Studies also found that multimodal travellers have a more balanced attitude towards all modes of transport than monomodal travellers who are more biased towards a specific transportation mode.

Furthermore, transportation poverty has been discouraging the use of multi-modal transport options. Transportation poverty is characterized by a lack of mode options particularly for socially marginalized people (low income, low education, precarious job situation). Transportation poverty is related to the lack of provision of transit in specific areas of the city, which problematizes social exclusion from participation in mobility (Groth, 2019).

2.3 Conceptual Model

The conceptual model (Figure 2) depicts the relationships between dependent and independent variables, the use of multimodal transportation, and factors affecting it, respectively.

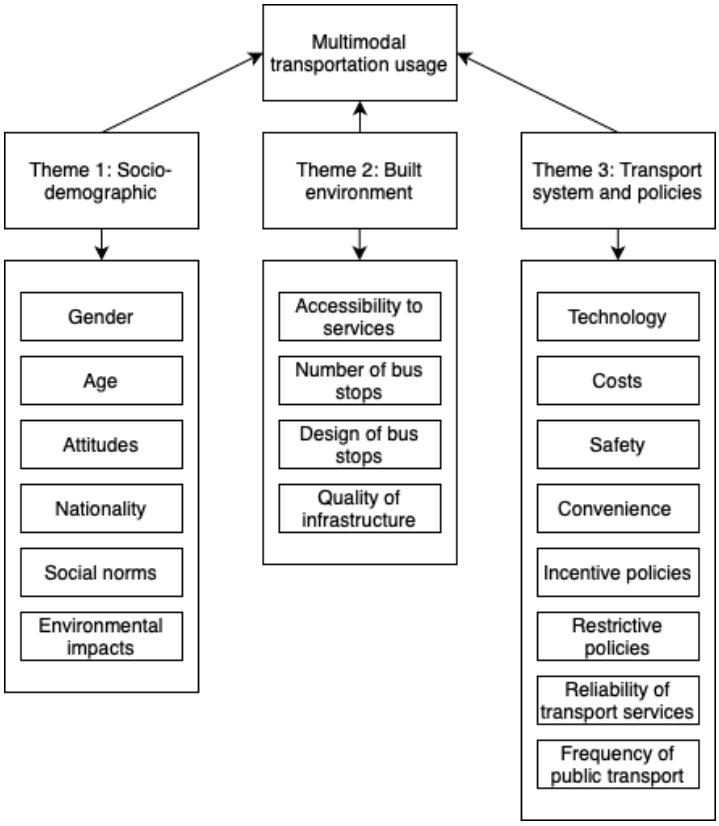

Figure 2. Conceptual model outlining factors affecting the use of multimodal transportation systems.

2.4 Expectations

Based on the literature discussed in the theoretical framework and the conceptual model, the following expectations have been formulated per theme.

- Theme 1: Socio-demographic

Since students are generally considered to be a low-income group, we expect that the likelihood for them to make use of multimodal transportation modes. The socio-economic status of students will play a significant role when choosing modes of transportation. Furthermore, based on the literature we expect female participants to exhibit higher levels of multimodality. A positive attitude towards sustainable modes of transportation would increase the chances of students selecting multimodal transportation.

- Theme 2: Built environment

The availability of public transport and bicycle infrastructure will positively affect the use of multimodal transportation modes in Groningen among students. Furthermore, we expect that the higher number of bus stops will encourage students to use sustainable modes more frequently. Lastly, high quality of infrastructure will have a positive impact on using sustainable modes of transportation among students.

- Theme 3: Transport system and policies

Transport service factors such as frequency of service, safety, and competitive travel times are expected to positively impact multimodal transportation in Groningen. We anticipate that students will choose the most convenient modes of transport, with perceived safety significantly influencing the choices of female participants. Additionally, the cost of travel will play a crucial role in students' decisions. The availability of up-to-date information will further encourage the use of various transportation modes. In Groningen, a combination of restrictive and incentive policies will work together to promote multimodal transport usage.

3. Methodology

3.1 Case Study

Groningen, situated in the northern region of the Netherlands, holds the esteemed title of regional capital. As delineated by the Central Bureau of Statistics (CBS), the demographic landscape of Groningen was marked by a population count of 235,000 inhabitants as of January 1st, 2022. Twenty-five per cent of the population accounts for students, thus giving the city the highest student population density in the Netherlands.

The Municipality of Groningen has certain policies influencing the usage of different transportation modes in the city. An important and relevant reason for the cycleability of Groningen is the “Het verkeerscirculatieplan” - the traffic circulation plan from 1977, functioning to this day. In the plan, the change in the built environment favoured public transport, bicycles and pedestrians above cars. The inner city was divided into four sections (Figure 3) and traffic directly through the city was made impossible by restrictions (Tsubohara & Voogd, 2004).

The most current mobility vision for Groningen, “Gone op Weg” (Albronda, 2023), contains the purpose of multimodal traffic management, where pedestrians and cyclists are positioned as the highest priority. The municipality focuses on creating a healthy living environment and changing travel behaviour towards more environmentally sustainable modes of transport. For traffic to and from key destinations within the municipality of Groningen, including the University Medical Center Groningen (UMCG) and the city centre, the multimodal network framework outlines the preferred routes that should be used whenever possible.

Furthermore, the Traffic Lights Policy Plan defines the maximum waiting times at traffic lights to be the measurement of quality, intending to limit wait times for traffic participants. Thus, for this ambitious vision, the municipality aims to minimize the waiting times of pedestrians and cyclists at intersections (to a maximum of 40 seconds). To achieve this, the intelligent traffic control installation (iVRI) was created. New techniques can be used to detect cyclists at an earlier stage, allowing traffic control to anticipate this and thus provide green lights sooner, decreasing waiting time. The iVRI has been placed at a few significant locations e.g. Zernike campus.

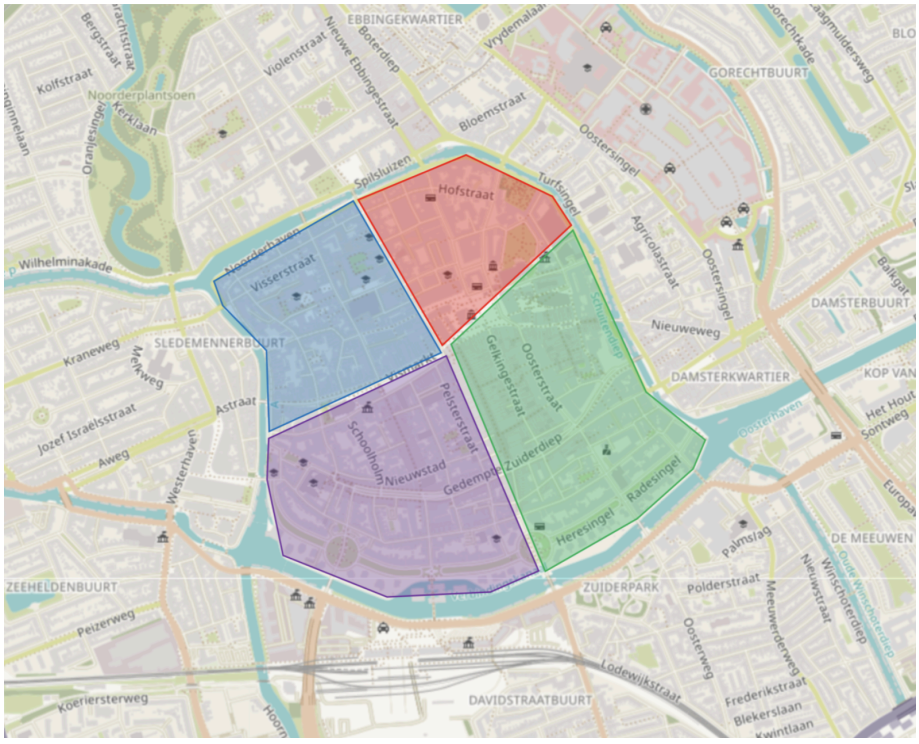

Figure 3: Visualisation of Circulation Plan Groningen

3.2 Semi-Structured Interviews

The study focuses on qualitative research, primary qualitative data to research factors and motivation for using multimodal transportation systems among students in Groningen. Qualitative data is used because concepts such as multimodal transportation are complex and cannot be quantified easily. Data provides an in-depth understanding of factors affecting multimodality.

Semi-structured interviews were conducted with a sample of students attending the University of Groningen. The interview guide (Appendix 7.1) was organized into nine sections. Participants were first introduced to the topic of research and asked for consent for recording. Then, day-to-day commute and the choice of transportation modes were discussed. After that, the frequency of usage and reliability of different transportation modes along with decisive factors for choosing those modes were evaluated. Next, participants were asked to share their experiences with multimodal transportation usage in Groningen and assess the quality of infrastructure accompanied by any suggestions for improvements to the transport system. Lastly, the semi-structured interview was concluded with the perceptions and policies section.
Students from the University of Groningen who reside in Groningen were recruited for the interviews. Announcements regarding participation in research were first posted in WhatsApp groups of students of different Faculties e.g. Spatial Sciences, Science and Engineering,

Economics and Business, and Honors College. However, after a few days passed, only a few students responded. Due to time constraints, it was decided to use convenience and a snowball sampling method.

The interviews were conducted with Bachelor students. Research aimed to collect 10 interviews with students, the length of one interview of 30-40 minutes for in-depth understanding (Jamshed, 2014). Interviews were conducted online via Google Meets or in a private studio at the university library and recorded on the Voice Memos.

After data collection, interviews were transcribed via the Fireflies.ai tool and analyzed via ATLAS.ti software. After transcribing and importing every interview separately, deductive and inductive codes were created in the Atlas.ti document according to the Coding Tree (Figure 5). Then, every code was assigned a corresponding quote manually. Lastly, once all codes were ready, the Code-Document Analysis Tool was used to see patterns of frequency of codes. These codes were then interpreted to help answer research questions. A similar method was employed in the Methods for Academic Research course in the second year of the Spatial Planning and Design Bachelor.

3.3 Ethical Considerations & Data Management

Since the research group consists of Bachelor students, no power relationships were established between respondent and researcher. In terms of positionality, the researcher was an insider. Before the beginning of interviews, participants were asked for verbal consent for participation and recording. Participants were informed of their rights to withdraw from participating at any time and participated in research voluntarily. The data was anonymized. After the research was completed, data files with transcribed and recorded interviews were deleted.

3.4 Coding Tree

The coding tree was designed based on a theoretical framework and conceptual model. Furthermore, inductive codes were added while analyzing primary qualitative data. Inductive codes are highlighted in green in Figure 5.

3.5 Characteristics of Participants

Participants	**Gender**	**Nationality**
1	Male	Dutch
2	Male	International
3	Male	Dutch
4	Male	International
5	Female	International
6	Female	International
7	Male	International
8	Female	International
9	Male	Dutch
10	Male	International

Figure 4. Characteristics of Participants

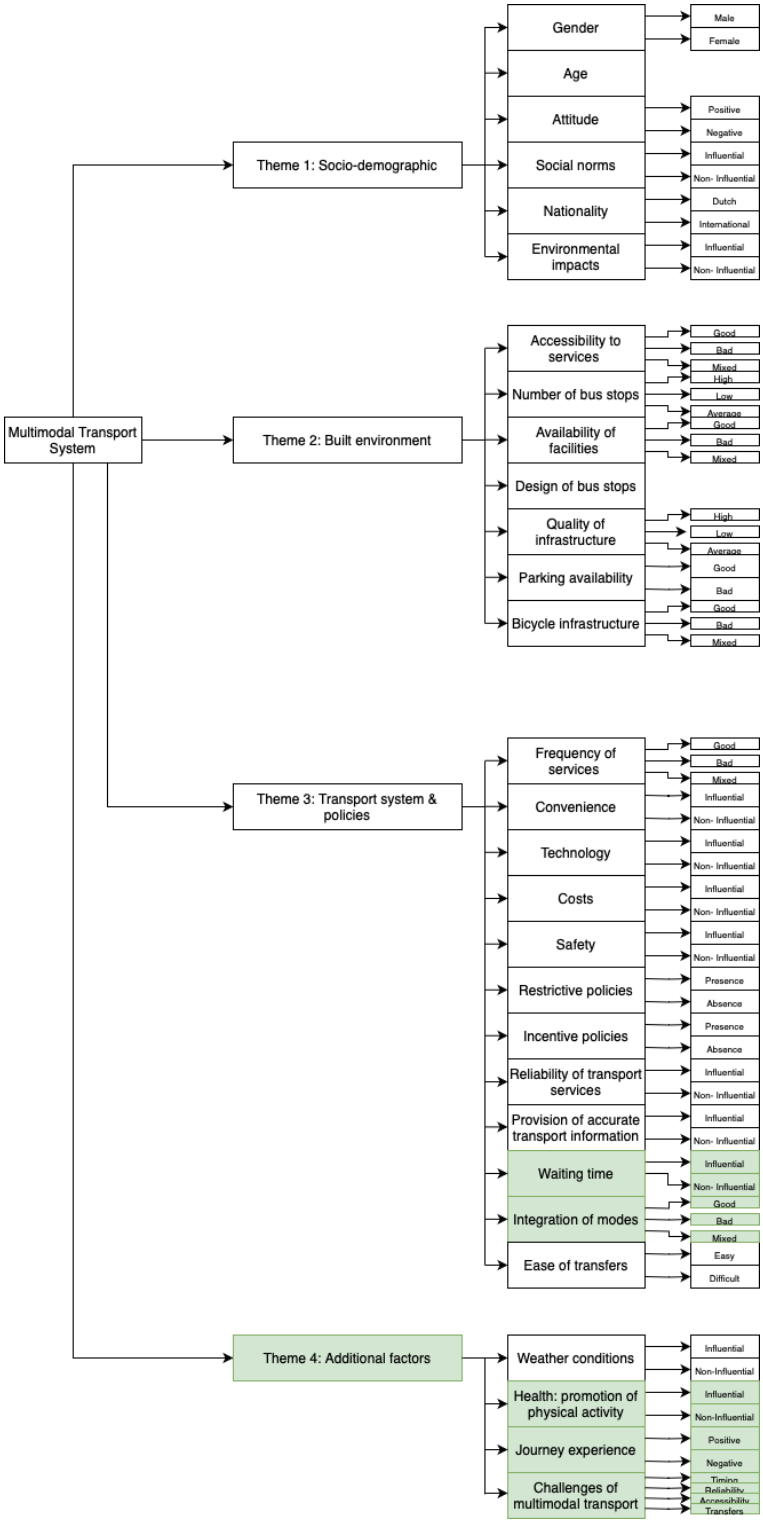

Figure 5. Coding tree used for data analysis. Green boxes illustrate deductive codes.

4. Results

Participants	Main transportation modes	Frequency of use	Decision factors	Typical multimodal journey
1	Bike; bus	Everyday; occasionally, when it's raining	- Convenience - Costs	A trip **outside** of Groningen, involving a train, bus, car
2	Bike; bus	Everyday; occasionally, when it's raining	- Weather - Waiting times	Trips **outside** of Groningen, involving a train, bus, airplane e.g. to visit the home city
3	Bike; car	Everyday; occasionally when lack of time	- Distance - Waiting times - Weather	A trip **within** Groningen, involving a combination of car and bus or train and bike
4	Bike	Everyday	- Time - Availability of modes - Safety - Environmental impacts	Trips **outside** of Groningen, involving a train, bus, airplane e.g. to visit the home city
5	Bike; bus	Everyday; occasionally, when it's raining *"In 2% of the cases I use the bus if it's impossible to get somewhere due to weather conditions"*	- Physical condition - Safety - Convenience - Weather - " If it's within the proximity of 10-15 minutes, then I take a bike"	Trips **outside** of Groningen, involving a train, bus, airplane e.g. to visit the home city
6	Bike; Felix (electric scooter)	Everyday; occasionally when lack of time	- Weather -Physical state - Availability of mode	A trip **within** Groningen, involving a combination of car and bike
7	Bike	Everyday	- Distance - Weather - Convenience - Costs	Trips **outside** of Groningen, involving a train, bus, airplane e.g. to visit the home city
8	Bike	Everyday	- Distance - Time	Trips **outside** of Groningen, involving train and bus
9	Bike; bus	Everyday; occasionally, when it's raining	- Flexibility - Convenience - Costs	Trips **outside** of Groningen, involving train and bus

			- Speed	
10	Bus	Everyday	- Convenience - Costs	Trips **outside** of Groningen, involving train and bus

Table 1: Showing the main results of qualitative analysis

Participants	Challenges	Suggestions for improvements	Attitudes and social norms	Awareness of policies
1	- Long waiting time at the bus stops	- Improving bus routes, *"it is hard to go from Point A to Point B in the city if it is not along the same line"* - Subsidizing travelling for students, making public transport free	- Environmental factors are not taken into consideration - Cycling culture in the Netherlands	- The government subsidizes free travel for Dutch students
2	- Unreliable buses - Small transfer window in between different modes	- Providing accurate up-to-date transport information via apps - Increase the number of bus stops, better distribute them around the city -Introduce more covered bus stops -Subsidizing and reducing travel costs for students	- Influenced by transportation choices of the other *"If someone I know takes a bus or takes a bike I can plan my trip to join them as well"*	- Renovation of centre, restricting entrance of cars
3	- Long waiting time at the bus stops	- Providing accurate up-to-date transport information via apps	- *"People in my direct network also prefer to walk and cycle"* - Cycling culture in the Netherlands	- Municipality focuses on developing small hubs with necessary facilities - *"They (municipality) are internally integrating a lot of measures instead of externally looking at how we can connect a lot of modes"*
4	- Delays	- Increase the number of bus stops, better distribute them around the city -Subsidizing and reducing travel costs for students	- Environmental factors are taken into consideration	- Renovation of centre, restricting the entrance of cars *" Well, something that happened recently, I think we all saw, is the Grote Markt and how they closed it off completely to cars"*
5	- Long waiting time at the	- Introduction of separate	- "depends on the group, if	-

	bus stops, low frequency of buses e.g. *"every 30 minutes"* *-" It's difficult to check the time of arrival of multiple modes of transportation"*	bike lanes in the center, so that cars and bikes don't cross (see Image 1)	I am travelling with someone, I would choose their mode of transportation"	
6	-	- Increase the number of bus stops, and disperse them	- Environmental factors are not taken into consideration	-
7	- *"I don't like the bus network here. It's always like you have to go to the centre and then go somewhere else"* - Delays	-Subsidizing and reducing travel costs for students	- Influenced by transportation choices of the other	- The government subsidizes free travel for Dutch students
8	- No bike parking at the bus stops - Poor bike infrastructure in the centre - Delays between modes	- Increase the number of bus stops, and disperse them - Introduce more parking spots next to bus stops	- Environmental factors are not taken into consideration, but sustainable modes are chosen unconsciously	- *"They (municipality) promote not parking your bike randomly, but only at the bike parking garage"*
9	- Getting a flat tyre/ bike being stolen - Bus disruptions	- Providing accurate up-to-date transport information via apps	- Cycling culture in the Netherlands	- *"The municipality and its infrastructure planning pays a lot of attention to the switch from bike to bus or bus to bike"* - Investments in hydrogen buses
10	- Cancellation of buses	-Subsidizing and reducing travel costs for students - Increase the number of bus stops, and disperse them	- Environmental factors are not taken into consideration, but sustainable modes are chosen unconsciously	- Municipality subsidizing helmets for cyclists

Table 2: Showing the main results of qualitative analysis

	1 Interview 1.docx 15	2 Interview 2.docx 20	3 Interview 3.docx 23	4 Interview 4.docx 8	7 Interview 7.docx 14	9 Interview 9.docx 16	10 Interview 10.d... 11	Totals
Theme 1: Socio-d... 5 0	3	3	3	1	2	1	2	15
Theme 2: Built en... 7 1	5	5	5	2	1	2	1	21
Theme 3: Transp... 12 0	7	10	12	4	9	11	8	61
Theme 4: Additio... 4 0	4	5	4	2	4	2	2	23
Totals	19	23	24	9	16	16	13	120

Figure 6: Code-Document Analysis for male participants

	5 Interview 5.docx 22	6 Interview 6.docx 10	8 Interview 8.docx 18	Totals
Theme 1: Socio-d... 5 0	3		2	5
Theme 2: Built en... 7 1	3	2	5	10
Theme 3: Transp... 12 0	11	5	9	25
Theme 4: Additio... 4 0	7	4	5	16
Totals	24	11	21	56

Figure 7: Code-Document Analysis for female participants

The interviews conducted for this study revealed a variety of experiences and perspectives regarding multimodal transportation among students in Groningen. Overall, there is a strong preference for cycling without multimodal switches, supported by the city's comprehensive bicycle infrastructure. Public transport is primarily utilized for longer journeys or during adverse weather conditions. Key factors influencing transportation choices include convenience, environmental consciousness, the availability of infrastructure, costs of travel and weather. Notably, participants highlighted the importance of reliable and frequent public transport services and the seamless integration of different transport modes.

4.1 Theme 1: Socio-Demographic Factors

Socio-demographic factors, such as socio-economic status, gender, and age, influence transportation choices. Huang, Ma and Jonas De Vos (2024) indicate that individuals from higher socio-economic backgrounds are more likely to use private vehicles, while those from lower socio-economic backgrounds rely more on public and active transport modes (Huang, Ma and Jonas De Vos, 2024). The interviews reflected this trend, with students indicating that cost considerations and environmental awareness influenced their preference for cycling and public transport over cars. However, certain individuals, primarily Dutch students in this case (Table 1: Participant 3), have modes of transport that are more accessible to them for weekly trips than to international students - such as having access to their families' cars. Furthermore, in the literature review, Heinen & Chatterjee (2015) indicated that females are prompted to exhibit higher levels

of multimodality compared to males. Qualitative data analysis suggests otherwise- according to Table 1 and Table 2 male and female participants both mainly used bikes and buses as their main modes of transportation and exhibited equal levels of multimodality. Heinen & Chatterjee (2015) hypothesized that females have more household responsibilities which require visiting a larger number of different destinations and consequently making use of more transport modes. The results we got are arguably due to the fact that bachelor students regardless of gender have an equal number of household responsibilities and hence the difference in results.

Peer influences and social norms are significant factors in choosing multimodal transportation usage. Six out of ten participants directly or indirectly mentioned the influence of Dutch cycling culture and social network on their transportation mode choices - Participant 3 *"People in my direct network also prefer to walk and cycle"*, Participant 2 *"If someone I know takes a bus or takes a bike I can plan my trip to join them as well"*. This highlights the importance of social factors in shaping transport behaviours, suggesting that policies promoting sustainable transport should also consider social marketing strategies to influence peer networks.

Lastly, according to literature, positive attitudes towards green modes of transportation and environmentally friendly travel promote multimodal behaviour (Huang, Ma and Jonas De Vos, 2024), however, according to interviews most of the participants mentioned that they do not actively consider environmental impacts when choosing transportation mode or combination of modes.

4.2 Theme 2: Built Environment

The built environment significantly influences transportation choices among students. Consistent with the literature, accessibility to public transport services and bicycle infrastructure (Ardeshiri & Vij, 2019) are crucial factors for multimodal transportation usage. In Groningen, specific infrastructure elements, particularly high-quality bicycle paths and the availability of covered bike parking at train stations, were frequently mentioned in interviews as important. For example, Participant 1 noted, *"Cycling paths in the Netherlands are really good."*

However, participants also identified challenges that constrain their use of multiple transportation modes, most of which relate to the design of the built environment (Tables 1 and 2). As discussed in the literature review, improving infrastructure quality can make sustainable transport modes more attractive (Suzuki, Cervero, and Iuchi, 2013). Several participants (4, 6, 8, and 10) mentioned the low distribution of bus stops in Groningen. For instance, Participant 4 stated, *"From where I live, one should walk 15 minutes to the next bus stop, and I think that makes it not accessible."* This issue can be attributed to the Municipality of Groningen's current Mobility Vision, which prioritizes pedestrians and cyclists.

Moreover, poor bike infrastructure in the city center was frequently mentioned. Participant 8 commented, *"...because it is an inner city, there are no designated cycling lanes. Everyone is driving on the same street; cars, trucks, bikes"* (Image 8). Additionally, the lack of designated bike parking at bus stops around Groningen restricts the option of using a bike and then switching to a bus. Some bus stops also lack covered seating facilities (Figure 9). These observations suggest a need for improvement in public transport facilities to better support multimodal transportation (Suzuki, Cervero, and Iuchi, 2013).

Figure 8: cycling lanes in Groningen; on the left - Boterdiep, on the right - Oude Ebbingestraat

Figure 9: bus stops in Groningen; on the left - Emmaplein, on the right - Verl. Visserstraat

4.3 Theme 3: Transport Systems and Policies

According to the Code-Document Analysis (Figures 6 and 7), factors related to this theme were frequently mentioned in the interviews. The transport system and related policies play a crucial role in shaping students' transportation choices. Literature suggests that incentive policies, such as promoting cycling, are effective in encouraging multimodal travel (Huang, Ma, and Jonas De Vos, 2024). The interviewees echoed this sentiment, with many students praising the city's focus on cycling infrastructure. For instance, Participant 4 remarked, “Well, something that happened

recently, I think we all saw, is the Grote Markt and how they closed it off completely to cars" (Table 2).

However, challenges related to the reliability and frequency of public transport services were also highlighted. This aligns with findings from Huang, Ma, and Jonas De Vos (2024) on the importance of service performance in facilitating multimodal travel. Participant 5 noted, "Long waiting time at the bus stops, low frequency of buses, e.g., every 30 minutes" (Table 2). Additionally, some participants mentioned bus delays as a challenge when switching between different modes, such as bus to train.

Many students reported using multiple apps to plan their journeys, such as Google Maps and NS (for trips outside of Groningen), indicating a gap in cohesive service integration. Enhancing coordination between transport modes and providing comprehensive, real-time information could improve the multimodal travel experience and increase its usage (Huang, Ma, and Jonas De Vos, 2024).

Lastly, to enhance multimodal transportation usage in Groningen, half of the participants proposed subsidizing and reducing travel costs for students, as costs are one of the most important factors in determining multimodal transport usage (Appendix 7.2)

5. Conclusions

This study investigated the factors influencing the use of multimodal transport systems among students in Groningen, revealing significant insights into their transportation preferences and challenges. The findings indicate that while cycling is the predominant mode of transport due to the city's extensive bicycle infrastructure and small size, public transport becomes crucial for longer distances and during adverse weather conditions. Key factors influencing transportation choices include convenience, environmental consciousness, infrastructure availability, and costs. Safety seems to be the least important factor. Challenges identified include the reliability and frequency of public transport services and the need for better integration and information provision across different transport modes.

The implications of these findings for soft and hard policies are multifaceted. Soft policies, such as social marketing campaigns, can leverage the strong influence of social norms and peer networks to promote sustainable transport choices. Hard policies should focus on improving the quality and distribution of public transport infrastructure, such as increasing the number of bus stops, enhancing real-time information systems, and ensuring better integration between different transport modes.

It is critical to discuss the limitations of the sampling methods employed in the research. Non-randomized sampling methods used may introduce research biases, leading to non-representative samples. Furthermore, participants recruited were uniquely distributed based

on gender and nationality characteristics (Figure 4), with 70% of the sample being male and 30% of the sample being Dutch students. Additionally, the research was done only based on the experiences of Bachelor students, however, the travel patterns and factors might differ for Masters and PhD students. Including both of these groups in future research could add more depth to existing literature. Thus, the interpretation of results must be processed with caution. Results and conclusions cannot be generalized. Future research should incorporate larger and more diverse samples.

6. Recommendations

Future research should consider larger and more diverse samples to explore the multimodal transportation behaviour of different student groups, such as postgraduate and international students. Further, examining the long-term effects of infrastructure improvements on transportation behaviour could help in assessing the effectiveness of urban planning interventions.

These findings and recommendations aim to support the development of more sustainable and efficient multimodal transportation systems in Groningen and other similar urban environments.

7. Appendix

7.1 Interview Guide

Introduction

- Briefly explain the purpose and importance of the interview.
- Assure confidentiality and explain how the data will be used.
- Obtain consent for recording the interview for research purposes.
- Introduce myself, optionally introduce yourself

Background Information

- How do you usually commute to the university?
- What places e.g. library, grocery store do you usually visit? And what transportation modes do you use?
- Have you changed your primary mode of transportation during your time in Groningen? If so, why? (in comparison with the past)

Transportation Modes

- What modes of transportation do you use regularly for your educational commute? (e.g., walking, biking, public transit, personal vehicle)
- How often do you use these modes of transportation? Everyday? Maybe you use different modes on different days?
- Are you using different modes when travelling to the university?
- What transportation apps or resources do you use to plan your routes or check schedules?
- How reliable do you find the transportation modes you use? Have there been frequent disruptions?

Decision Factors

- What factors influence your choice of transportation mode? (Ask follow-up questions regarding; Consider cost, convenience, time, safety, environmental impact, etc.)
- Which factors do you think are more important for you?
- How do seasonal changes or weather conditions affect your mode of transportation?

Experiences with Multimodal Transportation

- Can you describe your typical journey that involves using more than one mode of transportation?
- What challenges have you faced when using multiple transportation modes for a single trip? (Ask follow-up questions regarding; Consider timing, reliability, accessibility, transfers, etc.)

- How well do the different transportation modes integrate with each other? For example, are the schedules well-coordinated?

Infrastructure and Support

- How would you rate the availability and quality of infrastructure supporting multimodal transportation in your area? (e.g., bike lanes, pedestrian paths, public transit options) (Include accessibility to bus lines)
- Are there specific improvements or changes you believe could enhance multimodal transportation for students?
- Are there enough facilities for rest or shelter while transitioning between modes (e.g., covered bike parks, and waiting areas at bus stations)?
- How do safety measures (like lighting, security cameras, etc.) along your route influence your transportation choice, especially during night-time?

Perceptions and Preferences

- Which mode of transportation do you like more?
- What do people in your network or city think about sustainable modes of transportation?
- What attitude and social norms towards sustainable modes of transportation in your culture?
- Within your social network, what do people use?
- How does your experience with multimodal transportation compare to single-mode transportation in terms of overall satisfaction?
- Given a choice, would you prefer a single mode of transportation over multimodal options? Why or why not?

Policies and Initiatives

- Are you aware of any policies, programs, or initiatives by your educational institution or local government aimed at promoting multimodal transportation for students? (include example e.g. Paris)
- What kind of policies would encourage you to use multimodal transportation more?
- How has technology (like mobile apps or smart cards) impacted your use of multimodal transportation?

Conclusion

- Thank the participants for their time and valuable insights.
- Briefly explain the next steps in the research process.
- Offer an opportunity for the participant to ask questions or add any additional comments.

7.2 Code-Document Analysis for All Participants

	1 Interview 1.docx	2 Interview 2.docx	3 Interview 3.docx	4 Interview 4.docx	5 Interview 5.docx	6 Interview 6.docx	7 Interview 7.docx	8 Interview 8.docx	9 Interview 9.docx	10 Interview 10.d...	Totals
Accessibility of servi...	1	1		1	1	1	1	1		1	8
Accessibility of servi...	1	1			1	1	1	1		1	7
Accessibility of servi...				1							1
Accessibility of servi...											0
Age											0
Attitude											0
Attitude: Negative											0
Attitude: Positive											0
Availability of facilities		2	1	1	1	1	1	2	1	1	11
Availability of facilitie...		2				1	1	2		1	7
Availability of facilitie...			1	1	1				1		3
Availability of facilitie...			1								1
Bicycle infrastructure	2	2	1	1	1			2			9
Bicycle infrastructure...	1							1			2
Bicycle infrastructure...	1	2	1	1							5
Bicycle infrastructure...					1			1			2
Challenges of multim...	1	2	2		2	1	2	2	1	1	14
Challenges of multim...			1								1
Challenges of multim...		2					1	1	1	1	4
Challenges of multim...	1	1	1		2		1	1		1	8
Challenges of multim...	1	1	1		1	1	1	1		1	8
Convinience	2	3	1		1	1	1	1	1	1	12
Convinience: Influenc...	2	3	1		1	1	1	1	1	1	12
Convinience: Non-inf...											0
Costs	3	3	1		1	1	2	2	2	2	17
Costs: Influencial	3	3	1		1	1	2	1	2	2	16
Costs: Non-influencial								1			1
Design of bus stops								1			1
Ease of transfers						1	1	1	1	1	5
Ease of transfers: Dif...						1	1	1	1	1	4
Ease of transfers: Easy						1					1
Environmental Impacts	2	1	1	1			1	1	1	1	9
Environmental Impac...		1	1	1			1				3
Environmental Impac...	2	1						1	1	1	6

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