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Factors Influencing the Choice of Transport Mode among Students

A CASE STUDY OF THE CITY OF GRONINGEN

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Faculty of Spatial Sciences

University of Groningen

Supervisor: Dr. S. Ramezani

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List of Abbreviations

Abbreviation	Meaning
ACLO	Academische Centrale voor Lichamelijke Opvoeding
AF	Attitudinal factor
BBC	British Broadcasting Corporation
BE	Built environment
CBS	Central Bureau of Statistics
CDC	Centers for Disease Control and Prevention
FDMT	Federal Ministry for Digital and Transport
GIS	Geographic Information System
GPS	Global Positioning System
MoT	Mode of transport
N/A	Not applicable
PMT	Personal Miles Travelled
SPSS	Statistical Product and Service Solutions
TDM	Travel Demand Management
USCB	United States Census Bureau
UMCG	University Medical Center Groningen
UN	United Nations
VMT	Vehicles Miles Travelled

Abstract

This research looks at how students in Groningen travel to their university and focuses in particular on the mode of transport choice. The study examines the influence of attitudinal factors, the built environment, travel factors (travel costs and travel time) and socio-demographic factors (e.g. gender, age and nationality) on travel behaviour. To do so, a questionnaire has been conducted, resulting in a sample of 223 observations. To carry out the empirical investigation, factor analysis and binary logistic regression using the stepwise regression method have been performed. The outcomes of the empirical analyses show that it is mainly attitudinal factors, and four dimensions of the built environment that influence the travel behaviour of students in Groningen. Regarding the built environment, design and distance turn out to be the most important dimensions, followed by destination accessibility and diversity. Finally, international students seem to be able to adapt easily to the Dutch cycling culture as no significant difference has been found regarding travel behaviour. This study recommends the city of Groningen to maintain the high-quality cycling paths and to consider building more cycling highways to university locations in Groningen.

Keywords: Travel behaviour, transportation mode choice, built environment, attitudinal factors, socio-demographic factors, Groningen

1. Introduction

Cities are extremely important when it comes to human development. At the same time, people are increasingly more dependent on cities (Riffat et al., 2016). The UN (2014) estimated that by 2050 roughly 66% of humanity will live in cities, while this was only 5% two centuries ago. More people living in a city also comes with more responsibility for the city council as urbanisation causes new challenges, varying from sprawl to oil dependence to climate change, but also mobility (Ewing & Cervero, 2010). In modern daily life, people live, work, shop and sport at different places and need to travel from location to location (Bertolini, 2009; CBS, 2022). According to Schafer & Victor (2000), the average person living in a city spends 1.1 hours per day travelling in order to fulfil their wishes and perform their activities. This may be costly: Schafer & Victor (2000) claim that in Western countries 10 to 15% of the household income is being spent on transport and the Netherlands is no exception to this.

Many studies have looked at the travel behaviour in cities around the world, aiming to find what factors influence the travel behaviour of the population. Some studies focus on attitudinal factors and found significant effects regarding comfort, environmental attitudes and safety (Arroyo et al., 2019; Bagley & Mokhtarian, 2002; Eriksson, 2008). Other studies look at the built environment and found significant effects as well, especially concerning the design (Cao et al., 2009; Chen & McKnight, 2007; Handy et al., 2002). Then again, other studies explain travel behaviour by analysing socio-demographic factors, finding evidence that gender and age may play a role (Mitra & Nash, 2018).

This study will focus on the city of Groningen, in the North of the Netherlands. Groningen is a student city, as roughly 37% of the population in Groningen is a student (Groningen City Monitor, 2020). Due to the large number of students, and considering their busy lives, there is a lot of mobility in the city of Groningen, which makes good mobility infrastructure a crucial factor of a citizen's life. The study aims to understand how attitudinal factors, the built environment and socio-demographic factors influence travel behaviour of students. This leads to the following research question: *What factors influence transportation mode choice among students in the city of Groningen?* The main research question is supported by four sub-questions which help in answering the main research question:

- *What built environmental factors influence transportation mode choice among students in the city of Groningen?*
- *Do the attitudinal factors influence transportation mode choice among students in the city of Groningen?*
- *Is there a difference between Dutch students and international students with respect to transportation mode choice?*
- *Do the perceived built environment and the objective built environment influence transportation mode choice among students in the city of Groningen and is there a difference?*

The findings of this research can be used by the municipality, as some of the factors which may come forward from the study might be influenced by the municipality. This is especially the case when it comes to the built environment factors, as the municipality has a great influence on for example the design of the city. Furthermore, the results of specifically the third question could help the integration

of international students into the Dutch society. As the Dutch biking culture is so distinct compared to how other countries' culture concerning biking, this could lead to a huge difference in travel behaviour between Dutch and international students (CBS, 2022; FMDT, 2020; USCB, 2018).

Next to the societal relevance, this research also has scientific importance, as this study adds to the already existing literature on travel behaviour of individuals. Most of the existing literature looks at travel behaviour towards work. When looking at age groups the working population gets the most attention. There is far less attention for other groups of individuals, of which students is one. (Kim & Ulfarsson, 2004). This study adds to the literature by focusing on the travel behaviour and choices of students, specifically students living in student and cycling-oriented cities.

The research gap this study aims to fill concerns the built environment. In most studies, the built environment is measured around one's home location. This means that most studies look at how the built environment around one's home location influences the mode of transport this individual chooses when travelling (e.g. Chen & McKnight, 2007; Ye & Titheridge, 2017; Munshi, 2016). What has also been discussed in the literature is the built environment along the route people travel, and this has been proven to affect the choice of route for the individual (e.g. Saelens & Handy, 2008; Sarjala, 2019). However, the built environment around the destination has received less attention, which is why this study focuses on the built environment around the destination of the trip: the university.

This study will start by reviewing the existing literature regarding the subject. In particular, it will focus on the effects of the built environment, attitudinal factors, travel factors and socio-demographic factors on travel behaviour. The review will explain these determinants of travel behaviour, both in general, as well as with a focus on students as a sub-population. Based on the existing literature a conceptual model is constructed. Following up on that, the methodology, the research approach, the data collection process and data analysis will be explained. After this, all four sub-questions will be discussed and answered in the results section. This will be done by performing a binary logistic regression while following the stepwise regression method. Finally, after discussing and answering all four sub-questions in the results section, this study presents the main findings in the conclusion in which the main research question will be answered and recommendations for further research will be provided.

2. Literature Review

Travel behaviour is a well-studied subject in the field of transport geography and specifically in the fields of urban and transport planning . When scholars discuss travel behaviour and want to measure this phenomenon, they use different methods to measure travel behaviour. While Nasri & Zhang (2012) measure travel behaviour by calculating the vehicles miles travelled (VMT), other studies also include personal miles travelled (PMT) and sometimes compare the PMT to the VMT (e.g. Balepur et al., 1998; Cao & Fan, 2012; Kong et al., 2020). Other studies look at the travel behaviour in people's daily life and measure this by looking at a person's number of daily trips. These measures of travel behaviour are often mode-neutral. This means that another way to measure travel behaviour is by measuring the mode of transport choice: this does not look at the distance, but focuses more on why people prefer to use specific modes of transport over other modes of transport.

There are many factors that influence the choice of the mode of transport, and the subject has been studied extensively (see, e.g. Buehler, 2011; Cervero & Kockelman, 1997). Since the choice of mode of transport is a very broad topic, different researchers focus on different aspects. They may focus on a specific group of people, a specific context, or a specific factor that may influence the choice of mode of transport.

This literature review discusses the following factors that may influence the choice of mode of transport: built environment, socio-demographic factors, attitudinal factors and money related factors such as the costs of traveling. It will discuss these factors in general, as well as in the context of a specific group of people regarding travel behaviour, as this is the subgroup this study focuses on. In the final section of the literature review, the conceptual model that will be used for this research will be explained.

2.1 Built Environment and its Relation to Travel Behaviour

The first aspect that is discussed is the built environment. The built environment, as opposed to other influencing factors that will be discussed later, can specifically be influenced by urban planning. The built environment, as the word already suggests, consists of only physical features of the world we live in. This includes features such as schools, open spaces, intersections and bike lanes and all other features in our living climate (CDC, 2021). However, when researchers discuss the built environment concerning travel behaviour, they often divide the built environment into Ds.

In 1997, Cervero & Kockelman (1997) permanently changed the idea around travel behaviour and planning when they introduced the 3Ds. They stated that *density*, *diversity* and *design* were the main built environment factors that influence travel behaviour. Using a dataset covering the San Francisco Bay Area, Cervero and Kockelman found that denser neighbourhoods, diversity in land use and designs focusing on the pedestrian's needs lead to a lower number of total trips by car in the area. Later, the 3Ds were expanded to the 5Ds, as Ewing & Cervero (2001) introduced *distance to transit* and *destination accessibility* influencing travel behaviour. The original 3Ds of density, diversity and design still seem to be getting the most attention and are often seen as the most important dimensions in the built environment framework (Ramezani et al., 2021). However, as destination accessibility can also be closely related to diversity of land use, this component also gets a lot of attention in the literature.

The next five sections will each start with a short explanation of the components of the 5Ds and will then look at how each dimension influences travel behaviour.

2.1.1 Density

The first dimension of the built environment is *density*. In discussions on density, the term often refers to population density and employment density. These different types of density often go well together (Tobisch & Psenner, 2021). Population density and employment density can also be added together to calculate an activity density (Ewing & Cervero, 2010). Next to that, density can also be measured by looking at street network density, junction density or transit stop density (Tracy et al., 2011).

Density is especially important when trying to achieve more sustainable cities. If a city or neighbourhood is less dense, this will mean a higher level of automobile dependency as daily trips cannot easily be done by foot or by cycling (Ogra & Ndebele, 2014). According to Kenworthy & Laube (1996), "high densities tend to be associated with lower average trip distances for all modes, improved public transport through higher potential patronage around each stop and in particular, enhanced viability of walking and cycling" (p.281). In addition, Buch & Hickmand (1999) state that the use of public transport is higher in high employment rate areas compared to low employment rate areas. A city layout that aims to have high density can be characterized by "safe pedestrian, cycling and public transport networks" (Giles-Corti et al., p.2914, 2016).

The role of density when it comes to travel behaviour is rather inconsistent in the literature according to Chen & McKnight (2007). This is mainly because many studies tend to forget other influencing factors that go along with the density. Nonetheless, they found that even after controlling for all other influencing factors, density (employment density in particularly) tends to lead to a decrease in car usage.

2.1.2 Diversity

Diversity is often referred to as mixed land use "which means having a complementary and context appropriate combination of shops, services, housing types, offices and employment opportunities within the same area that allow people to meet most of their daily needs nearby" (Pongprasert & Kubota, p.187, 2018). Often, diversity can simply be measured by analysing a specific location and by measuring the number of different land uses in this specific location (Ewing & Cervero, 2010).

Cao et al. (2009) found that mixed land use leads to an increasing use of public transport and the use of non-motorised modes of transport. Regarding active modes of transport, the main reason why high diversity stimulates people to walk is because the distances between the various services decrease when the diversity increases, which makes general daily activity locations more accessible for the individual.

2.1.3 Design

Design is the third dimension of the built environment. Part of the design is the road network. Street networks in and around cities can differ from urban grids with streets being interconnected, to more suburban grids with curving streets (Ewing & Cervero, 2010). Next to the road network, amenities alongside these roads are also included in the design of the built environment (Ogra & Ndebele, 2014).

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 motorised vehicles (Suzuki et al., 2013). Examples of improving the quality of the street design and making routes more attractive, are adding zebra crossings, widening sidewalks, creating (safer) cycling lanes, and street canopy (Pongprasert & Kubota, 2018). Ramezani et al. (p.1351, 2018) found that improving "small scale street design quality alone increases sustainable mode choice for non-work trips". Finally, the design also influences the quality of stay. Not all walking purposes are linear, and therefore adding places to sit and rest needs to be taken into account in the street design (Tobisch & Psenner, 2021).

Measuring design can be done in several different ways. Often this includes "average block size, proportion of four way intersections, and number of intersections per square mile" (Ewing & Cervero, p.267, 2010). A study by Handy et al. (2002), who looked at the design, found that urban design in combination with promoting walking and cycling by creating better transportation systems and land use patterns will make the city healthier, more active and more liveable.

2.1.4 Destination Accessibility

Destination accessibility refers to how well destinations such as shops, events and educational buildings can be reached (Pongprasert & Kubota, 2018). Destination accessibility can be measured in different ways – examples of this are distance to the Central Business District and the number of jobs that can be reached within a certain travel time (Ewing & Cervero, 2010). Important to note is that it measures travel time, and not travel distance, as this is about measuring how easily accessible a certain area is.

Destination accessibility can be divided into local accessibility and regional accessibility (Handy, 1993; Tobisch & Psenner, 2021). Local accessibility is considered to be a walkable distance, while regional accessibility is everything outside a pedestrian's reach and thus "characterizes the connection to other centers or even cities" (Tobisch & Psenner, p.188, 2021). Cervero & Duncan (2006) find that fine regional transit accessibility leads to a decreased use of individual motorised vehicles and an increased use of public transport.

Destination accessibility shares some characteristics with the term 'accessibility', introduced in 2018 by Handy, who criticised how the built environment was depicted in the framework of the Ds. She wrote that the various Ds are very much interdependent rather than independent, which is what was claimed in the theory (Bento et al., 2005). As a consequence, the importance of one of the Ds can easily be overestimated. Instead, Handy claims accessibility is a better term, albeit a less catchy one, to characterize the built environment. She explains this by the German phrase for the goal of good accessibility: "ein stadt de [sic] kuerzen wegen, a city of short distances" (Handy, p.2, 2018). According

to Handy, a city of short distances would reduce the number of car trips and improve the quality of life in the city, which is why she advocates for the usage of accessibility rather than the 5Ds.

2.1.5 Distance to Transit

The final dimension of the built environment is the *distance to transit*. This can be measured in multiple ways, but most often it is measured as "an average of the shortest street routes from the residences or workplaces in an area to the nearest rail station or bus stop" (Cervero & Ewing, 2010). Distance to transit is especially important for longer distances, since using the bus or train is more practical for longer trips (Tobisch & Psenner, 2021). If the distance to transit increases, the density of transit stations quite often decreases.

2.1.6 Perceived Built Environment

Next to the five dimensions, the importance of perceived built environment will also be discussed. Perceived built environment concerns subjective judgments of individuals (Ettema et al., 2016). Whereas the objective built environment is measured with official data, the perceived built environment takes into account characteristics such as perceived safety or the maintenance of the road (Ettema et al., 2016). Existing studies generally look at the built environment around one's home location, whereas the built environment around the destination is being overlooked (e.g. Chen & McKnight, 2007; Munshi, 2016; Ye & Titheridge, 2017).

Research has shown that the perceived built environment can influence a wide array of different factors. Roberts et al. (2016) found a positive association with physical activity, while Cao et al. (2016) found increased perceived built environment characteristics such as diversity, aesthetics and safety to lead to a better mental and physical well-being. It has also been researched with the objective to see what influence the perceived built environment may have on the mode of transport choice and studies found there is indeed a correlation, as perceived walking safety leads to more people choosing to walk to nearby destinations (Li et al., 2005). When comparing the perceived built environment with the objective built environment, scholars found that these do not always agree (Ma & Dill, 2015; McGinn et al., 2007). Ma & Dill (2015) focussed on the differences between perceived and objective built environment as they only looked at cycling as a mode of transport. They found that bicycle paths and minor streets (objective built environment) led to a higher cycling preference. The perceived built environment, however, could not predict cycling preference and only predicted cycling frequency.

2.2 Attitudinal Factors

Next to the built environment, in the literature also attitudinal factors have been considered as influencing travel behaviour. The term 'attitudinal factors' is not exclusively used in the geographical context. As attitudinal factors simply entail the attitude people have towards something, it is used extensively. In the medical field, for example, a study has been conducted into the attitudinal factors towards blood donation (Boulware et al., 2002), while another study in an entirely different field looks at the attitudinal factors towards learning English (Mustafa et al., 2015). As studies concerning

attitudinal factors focus on different subjects and people's attitudes towards them, every study uses different ways of measuring attitudes.

In the geographical field, attitudinal factors have also been studied extensively. Studies have found that attitudinal factors often indirectly influence travel behaviour (van Acker et al., 2008). However, they suggest that attitudinal factors get less attention than socio-demographic factors and the built environment. The latter two are often controlled for, while attitudinal factors are sometimes disregarded by scholars as factors influencing travel behaviour (van Acker et al., 2008). However, over the years attitudinal factors have received increasingly more attention in travel behaviour research and are now recognized as one of the main determinants of travel behaviour. Kitamura et al. (1997) found that attitudinal factors explain the highest percentage of variation with regard to travel behaviour. Dobson and Tischer (1977) even concluded that attitudinal factors were responsible for 63% variance in travel mode decisions. Moreover, Kuppam et al. (1991) came to a similar conclusion when they found that, to their own surprise, attitudinal factors had an even greater influence than socio-demographic factors. Attitudinal factors that influence travel behaviour, such as beliefs, environmental attitudes, convenience, values, and norms, will be discussed in the following paragraphs (Eriksson, 2008).

Kuppam et al. (1991) used a dataset with close to one hundred questions, all covering different types of factors regarding the attitude of work-commuters in the Puget Sound region in the U.S. state of Washington. The applied factor analysis, dividing these questions into eight categories. The factors are all mode of transport-related, and four of the eight factors cover the convenience of a mode of transport, which is an important part of the attitudinal factors regarding travel behaviour. Bagley & Mokhtarian (2002) agree with this, as they also look at the comfortability of driving and public transport. This is closely related to what Koppelman & Lyon (1981) call personal normative beliefs, a term that formed an important part of the Theory of Planned Behaviour by Ajzen (1991). Personal normative beliefs are based on what one thinks one should do regarding the choice of mode of transportation. It is good to note however that a personal belief towards a mode of transport can be something different than someone's preference towards certain modes of transport. One's belief toward specific modes of transport is closely related to the liking or disliking of this specific transport (Koppelman & Pas, 1980).

Environmental factors may also influence one's travel behaviour. Travel behaviour and the increasing travel demand have a negative effect on global emissions (Girod et al., 2013). Bagley & Mokhtarian (2002) looked at the pro-environmental factors, as one of the aspects of attitudinal factors. For their research, they studied the San Francisco Bay Area and used an already existing dataset with more than 500 respondents. One of the factors classified under the attitudinal factors was the pro-environment factor. This concerned statements such as "people and jobs are more important than the environment", "environmental protection is good for the economy" and "stricter smog control laws should be enforced" (Bagley & Mokhtarian, p.283, 2002). They found that the pro-environment factor, although solely a consequence of indirect effects, is significantly associated with suburban residential locations compared to urban locations. However, a study by Naess (2006) showed no significant influence on the attitudes toward environmental problems. On the other hand, an extensive study by Eriksson (2008) showed that in specific situations environmental norms and beliefs are of great importance in the "acceptability of transport policy measures" and that citizens are willing to change

their travel patterns (Eriksson, p.3, 2008). Nilsson & Küller (2000) conducted two empirical studies in Sweden and found similar results, suggesting that "local implementation of new strategies to reduce private car driving might benefit from a better understanding of what will be accepted among the public" (Nilsson & Küller, p.211, 2000). All things considered, scholars do not fully agree on the effect of environmental factors and concerns and their influence on travel behaviour.

Attitudinal factors regarding travel behaviour can also be attitudes towards external factors, factors the individual cannot influence. The main external factor that influences travel behaviour is the weather. The weather is becoming more extreme and more persistent due to climate change (Böcker et al., 2012; Liu et al., 2017), which may increasingly impact the travel behaviour of individuals. This is especially the case when roofed modes of transport such as car and public transport are compared to non-roofed modes of transport such as walking and cycling. Also, extremely high or low temperatures and unexpected heavy snow can very much influence one's travel behaviour. Liu (2016) found that in Sweden there is a clear difference in the impact of the weather between the North (where it is generally colder) and the South (where it is generally warmer). He claims that in the South, extreme temperatures lead to less walking while in the North the opposite is the case. Next to that, people tend to cycle more in the summer, while in the winter they opt more often for walking and public transport. Less usage of public transport during the summer is what Zhou et al. (2017) also found in their study. Finally, Liu (2016) claims that winter precipitation leads to less walking while summer precipitation leads to more walking. Cyclists seem to be rather dependent on the weather forecast as 30% of the respondents in a Singaporean data set check the weather forecast before they decide to take the bike. This group is also more likely to change their travel behaviour due to the weather (Meng et al., 2016).

As discussed in this paragraph, attitudinal factors influence travel behaviour. However, there are also factors that influence attitudinal factors – the first of these being habit. According to Verplanken et al. (1994), as the habit of the individual gets stronger, the influence of attitudinal factors becomes weaker. The second of these influencing factors that will be discussed briefly is the values of an individual. Paulssen et al. (2013) looked at the influence of values on travel mode choice behaviour and found that personal values do influence the attitudinal factors of individuals towards the choice of mode of transport. They found that personal values especially impact one's "flexibility, comfort and convenience, and ownership, which in turn influence mode choice behavior" (Paulssen et al., p.886). Arroyo et al. (2019) claim that values influence the mode of transport choice both indirectly (through the attitudinal factors) and directly. They found that individuals who value stimulation and achievement are more likely to travel by public transport. These were values that used to be related to more car use but have now shifted to the use of other modes of transport. At the same time, someone who values power is less likely to walk (Arroyo et al., 2019). Finally, they also talk about the value 'security' (safety/harmony). Women often highly value security and safety and are therefore less likely to use active modes like walking and cycling due to the absence of harmony between users of different modes of transport (Arroyo et al., 2019; Mitra & Nash, 2018).

2.3 Socio-Demographic Factors

Next to attitudinal factors and the built environment, socio-demographic factors may have an impact on travel behaviour as well. In travel behaviour studies, the most studied socio-demographic factors

are age, gender, education level, income, and household size (e.g. Bagley & Mokhtarian, 2002; Filimon et al., 2022; Hansson & Huff, 1986; Jensen, 2011; Slabbert & Du Plessis, 2013). Often, the these factors are used as control variables to measure the effect of other factors such as the attitudinal factors or the built environment. Nonetheless, scholars often find socio-demographic factors to be the main, and sometimes even only, factors of influence on the travel behaviour of individuals (e.g. Kattiyapornpong & Miller, 2009; Slabbert & Du Plessis, 2013). In the following paragraph, findings regarding the socio-demographic factors will be discussed.

First of all, when looking at age, the elderly age group has received quite some attention. They are likely to travel by public transport when a transit is nearby their home, but less likely when they also need to run errands (Kim & Ulfarsson, 2004; Schmöcker et al., 2008). When undertaking a short and purely recreational trip, they often prefer walking (Kim & Ulfarsson, 2004). However, disabilities tend to prevent the elderly from using public transport, in which case their preference shifts toward taxis (Schmöcker et al., 2008). The working-age group generally prefers a car over other modes of transport (Buehler, 2011). Next to age, education and income also have a significant effect. Higher education level as well as higher income level, characteristics that are often intertwined (Wolla & Sullivan, 2017), both lead to more use of cars compared to public transport, cycling and walking (Buehler, 2011; Kizony et al., 2020). A higher education level leads to a better understanding of GPS technology and smartphone navigation (Kizony et al., 2020), while a higher income level leads to higher car ownership (Clark, 2007). Furthermore, when looking at gender, the greatest difference can be observed in cycling, as women tend to cycle a lot less than men (Mitra & Nash, 2019; Prati et al., 2019; Shafizadeh & Niemeier, 1997). However, since women highly value cycling safety and experience higher risk perception, good cycling facilities decrease the gender gap with respect to cycling (Buehler, 2011; Prati et al., 2019).

Good cycling facilities are often also connected with a cycling culture like in Denmark, Germany and the Netherlands (Haustein et al., 2019). In the United States, it is not as safe to cycle as compared to these European countries, which causes only 1% to travel by bike (Buehler, 2011). The same research found that Germans cycle almost eight times more than the average American. However, the Dutch cycle more than any other country, as 27% of all trips in 2018 in the Netherlands were conducted by bike (Government of the Netherlands, 2018). Considering this, travel behaviour and especially cycling behaviour differs per country – making nationality an important socio-demographic factor.

2.4 Travel Factors

A final important factor that will be discussed in this thesis is travel factors, that is, travel costs and travel time. Transport demand management (TDM) aims to lead people into a more sustainable and effective mode of transport. TDM can be described as “any activity, method or program that reduces vehicle trips, resulting in more efficient use of transportation resources” (Dorsey, p.237, 2005). Demand management is a way to measure travel costs and consists of two main components: parking costs and trip costs (Giles-Corti et al., 2016; Pongprasert & Kubota, 2018). Concerning the two main components of TDM, pricing and parking, policies are set in place to increase the attractiveness of using alternative transport modes to the car (Giles-Corti et al., 2016). Articles have shown mixed results regarding the parking costs, as Albert & Mahalel (2006) found that congestion tolls have a greater

influence on travel behaviour than parking fees, although both are supposed to reduce the number of car users and increase non-motorised modes of transport. However, at the same time, Christiansen et al. (2017) found parking fees to be effective in large parking lots while limited parking time is more effective in smaller parking lots.

The other factor that will be discussed is travel time. A study by Chorus et al. (p.163, 2010) found that individuals on "non-business trips attach particular importance to mean travel times". With respect to travel time, according to Frank et al. (2008) this is a stronger predictor of mode choice than travel costs. They found that better conditions for travelling by car, such as reducing travel time on the highway, will indeed lead to less use of other modes of transport such as walking, cycling and public transport. When looking at the travel time of public transport, it is important to take into account waiting time. If the waiting time is longer than accepted by the passenger, the passenger tends to switch travel modes. This is also the case when bus arrival times are unpredictable, in which case passengers will decide to ride a bike or call a taxi (Han et al., 2018).

2.5 Travel Behaviour of Students

As explained before in the socio-demographic section, travel behaviour studies often focus on the travel behaviour of the working-age or the elderly. Less attention has been directed towards the travel behaviour of students and young adults (Blumenberg et al., 2012; Kim & Ulfarsson, 2004). Nonetheless, this section looks at how existing literature views the travel behaviour of students. It will discuss to what extent the built environment, attitudinal factors, socio-demographic factors and travel factors influence students' travel behaviour and in particular their choice of mode of transport.

First of all, this study will look at the built environment. Design is one of the dimensions of the built environment that can influence students. According to Mitra & Nash (2018), who studied the travel behaviour of students in Toronto, female students cycle less compared to male students, which is in line with other results from e.g. the study by Simons et al. (2017). However, accessible bicycle lanes tend to increase the chance of choosing to cycle for female students in particular, as women value safety higher than men do (Arroyo et al., 2019). Nonetheless, Mitra & Nash (2018) conclude that the built environment cannot solely explain the difference in the gender gap when it comes to cycling. Tracy et al. (2011) claim that besides design, density also affects students' travel behaviour. They found that high street network density positively correlates with the use of public transport, while the accessibility of the street network is associated with high percentage of pedestrians (Lamíquiz & López-Domínguez, 2015; Vale et al., 2018). Design and density seem to have a greater influence than the other built environment dimensions concerning students' travel behaviour.

Secondly, this paper will discuss the attitudinal factors and their influence on students' travel behaviour. Little research has been done on the attitude factors that influence travel behaviour of specifically students. The main attitude that influences the mode choice of students is travel satisfaction (De Vos et al., 2021), as they claim that a positive experience with a specific mode leads to a positive attitude towards that mode. Pro-environmental attitudes tend to lead to the use of non-motorised modes of transport, also among students (Etminani-Ghasrodashti et al., 2018). When looking at public transport use among students, Sam et al. (2014), who studied the students of the

University of Cape Coast in Ghana, found that students especially valued safety, comfort and reliability when using public transport. However, not only the travel attitudes of students influence their own travel behaviour. Parental attitudes also affect this (Emond & Handy, 2012). According to McMillan (2007), children are less likely to travel by bike or by foot if their caregivers consider the car to be more convenient, which is in line with Emond & Handy's findings (2012). There is no great difference in age among students when looking at their attitudes. Younger students at Arizona State University tend to make fewer campus trips but there is no findings on their mode choice (Volosin, 2014).

Finally, costs seem to influence the travel behaviour of students as well. Vale et al. (2018) found that for students travelling by car, free parking spots are crucial as this works "as a magnet for students commuting by car, despite the high financial cost of this travel mode" (p.13). With respect to travel costs, a study at the national university of Malaysia found that when asking the participants whether they are open to switching from individual motor vehicles to public modes of transport, participants are often not keen to do so as the alternative is more expensive (Mohammed & Shakir, 2013). With respect to public transport, students perceive time management (minimizing travel time) as a key factor for preferring public transport over other modes of transport (Etminani-Ghasrodashti et al., 2018), especially in larger cities where traffic congestion is a pressing issue.

2.6 Conceptual Framework

Based on the literature discussed, a conceptual framework has been constructed. The conceptual framework can be viewed in figure 1. The factor on the top left concerns the 'built environment around the destination', i.e. the university. The five different dimensions of built environment can influence travel behaviour in different ways. The three most important dimensions when it comes to travel behaviour are density, diversity, and design. According to the literature, high density, mixed land use and (road network) design are the principal ways in which the built environment influences travel behaviour as these will lead to increased use of public transport, cycling and walking (Cao et al. 2009; Chen & McKnight, 2007; Handy et al., 2002).

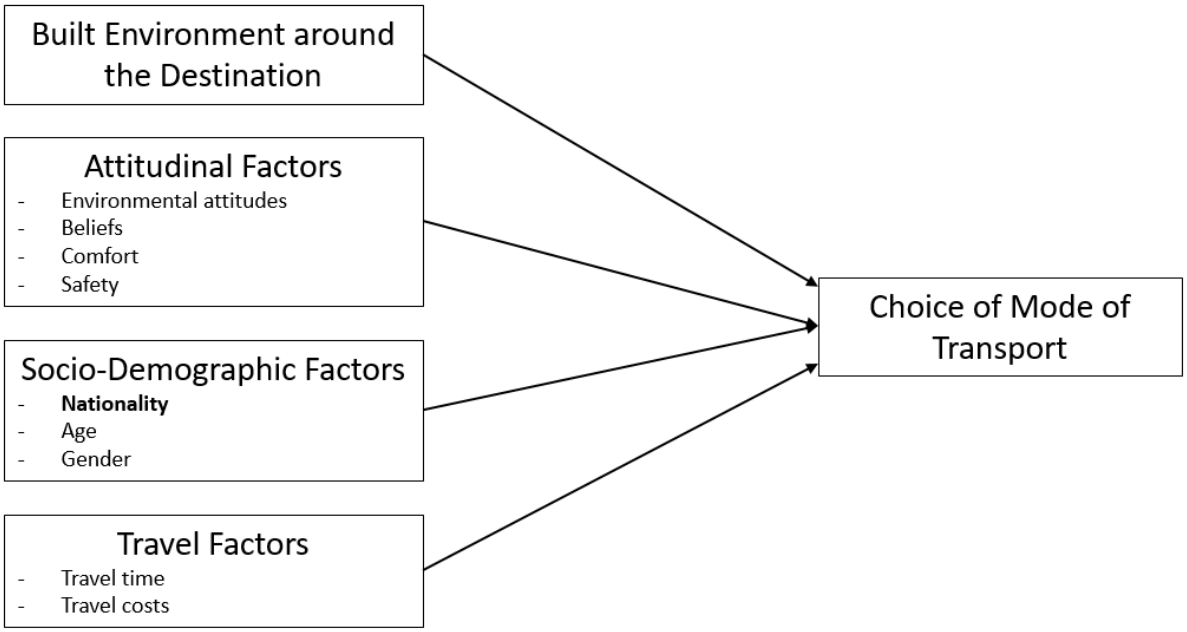
The second influencing factor on the mode choice of students is the attitudinal factors. The main attitudinal factors that influence travel behaviour are safety (Arroyo et al., 2019; Mitra & Nash, 2018), beliefs (Koppelman & Lyon, 1981), comfort (Bagley & Mokhtarian, 2002), and environmental attitudes (Bagley & Mokhtarian, 2002; Eriksson, 2008). While less safety leads to less cycling and walking (Arroyo et al 2019), positive environmental attitudes will lead to an increased usage of cycling and walking (active modes of transport) and a specific decrease in car use as mode of transport (Bagley and Mokhtarian, 2002; Eriksson, 2008). Concerning the latter, not all researchers agree on its influence on the mode of transport choice.

The third influencing factor concerns the socio-demographic factors. Nationality is shown in bold font as this is one of the sub-questions in this research and is therefore a more important socio-demographic factor. Due to the differences when it comes to cycling culture per nation, there can be rather big differences in travel behaviour. While 27% of the Dutch citizens travel by bike, only 1% in the people in the United States do (Government of the Netherlands, 2018; Buehler, 2011). Other influencing factors are age and gender. While the working-age group prefers the use of cars over all

other modes of transport (Buehler, 2011), students are more likely to cycle (Mitra & Nash, 2018; Simons et al., 2017). However, there is a significant gender gap when looking at cycling specifically, as several studies found that men are more likely to cycle than women (Mitra & Nash, 2018).

The final influencing factor in the conceptual model refer to travel factors such as travel costs and travel time. Parking fees mainly influence travel behaviour and can persuade individuals to choose another mode of transport over the car (Vale et al., 2018). However, an alternative study claims that students in particular are not willing to switch from individual motor vehicles to public transport as it is more expensive (Mohammed & Shakir, 2013). This does seem to be city-dependent. When looking at the travel time, better conditions for travelling by car (meaning less traffic congestion and less travel time on the highway) lead to more use of the car and less of other modes of transport (Frank et al., 2008). However, when the waiting time is too long, individuals seem to easily switch modes (Han et al., 2018).

Figure 1. Conceptual framework



3. Methodology

3.1 Research Approach

The aim of this research is to find out what factors influence the mode of transport students in Groningen choose when travelling to their university. The research question will be answered with a focus on the built environment as well as attitudinal factors, socio-demographic factors and travel factors. As there is no available open data that can answer the research questions, primary data has to be collected. Both qualitative and quantitative data can be useful in different research designs; however, as this research tries to make a generalized conclusion about the studied population, quantitative research is preferred (Bachman, 2016). Qualitative research can also be interesting, as this provides an insight into the reasoning behind students' choices. Yet, a qualitative research would not allow this research to generalise the results due to the much smaller sample size it would deliver, which therefore makes quantitative research more suitable.

3.2 Data Collection

3.2.1 Study Area

The study area of this research is the students at the universities in the city of Groningen. Groningen is a city in the north of the Netherlands and can be classified as a student city, where roughly 230,000 inhabitants 36.7% are students, which makes Groningen the youngest city in the Netherlands (Groningen City Monitor, 2020; Holligan, 2013). Groningen can also be considered a cycling city, which makes the city no different from the country it is located in: the Netherlands are often considered as the cycling country of the world (BBC, 2013; Van der Zee, 2015), as the Dutch cycle a lot more than the inhabitants of other Western countries. While in the Netherlands almost 30% of the people cycle to work (CBS, 2022), in Germany and the United States this percentage was only 11% and 0.5% respectively (FMDT, 2020; USCB, 2018). The only country that comes close is Denmark where 20% of the people commute by bike (Ministry of Transport, 2012). Next to that, the Dutch own more bikes than any other country in the world – in fact, there are more bikes than inhabitants (The Netherlands Compared, 2019). The BBC wrote an article about the cycling culture in Groningen and the Netherlands, and the difference between cycling in the United Kingdom was overwhelming (Holligan, 2013): cycling facilities are omnipresent, and cyclists are often completely segregated from motorised vehicles on the road. This is also why *The Guardian* (Van der Zee, 2015) called Groningen "a bicycle city par excellence", referring to the well-developed infrastructure for cyclists.

The study area includes both the University of Groningen as well as the Hanze University Groningen. Most of the students studying at these two universities live in the city of Groningen (Study in Holland, 2022). As the research looks at how students travel to their university, it is therefore important that the respondents travel to Groningen regularly. Long-distance students who study at one of the universities in Groningen are therefore excluded from this research.

Since there are two universities in Groningen, it is important to have respondents from both universities. The campuses of the University of Groningen are widely spread over the city, and therefore data will be collected data at both the Zernike Campus and university locations in the city centre. The Hanze University has several locations in the city of Groningen, although most respondents

study at the Zernike Campus as this is by far the biggest location. Table 1 shows all study locations included in this research.

Table 1. All university locations of the study area

Name of location	University
Academy building	University of Groningen
Harmony building	University of Groningen
Heymans building	University of Groningen
Minerva Praediniussingel	Hanze University Groningen
Minerva Zuiderdiep	Hanze University Groningen
Prins Claus Conservatory	Hanze University Groningen
UMCG (East side)	University of Groningen
UMCG (West side)	University of Groningen
Wiebenga	University of Groningen
Zernike Campus (Hanze University)	Hanze University Groningen
Zernike Campus (University of Groningen)	University of Groningen

3.2.2 Maptionnaire Survey

To reach the students of Groningen and ask them the relevant questions, a Maptionnaire has been constructed. Maptionnaire is a software program that is used to make questionnaires but has one extra feature. This feature allows the researcher to ask a map-based question: respondents answer this question by pinpointing a location on the map.

The Maptionnaire survey in this study included eight different sections. First, the respondent was introduced to the research and learned how the data would be used. In addition, respondents were also informed about the 20 euros voucher that they could win as a reward for their participation, which is put in place to motivate students to fill in the Maptionnaire. The second and third section consisted of simple and straightforward introductory questions regarding their socio-demographic background, which were needed to learn about the respondents' background; these were questions concerning age, gender, employment status, etc. The fourth section contained two map-based questions, where respondents had to pinpoint their home location as well as their university location. With respect to their home location, in order to protect the privacy of the respondents, respondents could pinpoint the crossing closest to their home rather than their actual home location. The fifth section then focused on travel time and travel costs, section six on the built environment factors, and section seven on the attitudinal factors. The questions formulated in the sections regarding the built environment and the attitudinal factors were based on the literature discussed in the literature review. These questions are in a Likert-scale format. Other scales such as a semantic differential scale had been considered but the

Likert-scale turned out to be a better fit in combination with the use of Maptionnaire. A semantic scale included a seven-point scale, which is not compatible with the display Maptionnaire offered. This was unfortunate but did not limit the research. The final section of the Maptionnaire allowed respondents to add a comment to the questionnaire and included a thank you to the students for their time and their participation in the research. The questions of the Maptionnaire can be found in appendix 1

3.2.3 Recruitment Process

In order to reach enough students, several different posters were made to advertise the research. All posters can be found in appendices 2, 3 and 4. These posters were posted on social media, but they were also put up around the city of Groningen. The posters were mainly put up at university locations in the city but also at other places where many students come, such as the Groningen sports centre for students (ACLO). Next to that, links of the Maptionnaire were sent around in WhatsApp groups in order to reach potential respondents. This kind of sampling is called convenience sampling (Burt et al., 2009). As this sampling method alone did not lead to enough respondents, more respondents were gained by actively meeting with students in the city centre of Groningen, university buildings and city parks such as the Noorderplantsoen, meaning this research resorted to simple random sampling at the end of the data collection process (Burt et al., 2009). Respondents were recruited on different days and different times of the day in order to avoid sampling bias as much as possible (Burt et al., 2009). Collecting data only on sunny days could for example have led to a bias towards cycling or walking, while only collecting on rainy days could have led to a bias towards public transport.

3.2.4 Ethics

It is important to know how the collected data will be used for this research, especially for the respondents of the Maptionnaire, as the respondents need to know the data is carefully taken care off. First of all, participating in this research was completely voluntary, meaning no respondent was forced to fill in the Maptionnaire. This research aims to minimize its harm and maximize its benefits (Clifford et al., 2016). In addition, all answers were completely anonymised. All responses were coded as numerical data in order to be analysed. To secure the safety of the data and therefore the privacy of the respondents, the data is only accessible by either the researcher and/or the supervisor. At the conclusion of the Maptionnaire, respondents were able to fill in their email address to win a reward. These email addresses were only used in order to contact the winners and were not used for any other purpose. Also, the email addresses were saved separately, which meant that they were not linked to any of the data. The researcher also left his own email address so that respondents could contact the researcher for further questions or any other reason.

3.3 Data Analysis

3.3.1 Data Preparation

Before running the data analyses to help discover the factors that influence travel behaviour among students in Groningen, the raw data needed to be prepared for usage. Initially, this meant enumerating

all the data in an Excel file. Next, the data needed to be looked at critically as some answers simply did not make sense (e.g. one respondent claimed he/she was two years old) or were seen as outliers. These observations were deleted from the sample. Next, the data needed to be as suitable for the data analysis as possible. Therefore, some of the locations were merged as they were simply too close to each other and therefore the travel behaviour should not differ between the locations. This has been done, for example, for the Oude Boteringestraat and the Academy building, as well as for the Oude Kijk in ’t Jatstraat and the Harmony building.

The geographical data also needed to be checked. Firstly, not all respondents pinpointed their home location and their university location. Out of the 223 respondents suitable for the statistical data analysis, 199 respondents fully completed the Maptionnaire – a 10.8% decrease in respondents compared to the statistical data analysis. Next, a handful of respondents only filled in their home location, but not their university location. This problem could easily be solved as the university location was retrievable from previous questions in the Maptionnaire where the Maptionnaire asked the respondent to write down the name of their university location. The data was added to the Excel file. Some respondents did not pinpoint the home location and therefore the lateral distance could not be computed. For these respondents, the distance was unknown and observations for these respondents were therefore reported as missing values.

Next, an extra variable has been added to the dataset for the SPSS analysis, since the location of both the respondents’ home and their university was known, the distance between the two locations could easily be measured. This variable was added to the dataset. It was decided to measure this variable by geographical latitudinal distance rather than ask the respondents the distance between their home and their university as the latter method might have led to more subjective answers. A flaw of measuring the lateral distance is that it does not take into account the road network and infrastructure of Groningen. Ring roads, canals and train tracks may cause a big difference between the lateral distance and the actual travelling distance. This shall be taken into account when drawing conclusions concerning distance.

Some data were recoded to create variables that could be used in the regression analysis. Firstly, the university degree was recoded to ‘Bachelor’ (0) and ‘Master/PhD’ (1). In the entire dataset, there were only two PhD students so there was no need for PhD students to have their own category; instead, the two PhD students were combined with the master’s students to create one category. Secondly, the question concerning one’s employment status was recoded. As the vast minority of students work full-time (5.8%), this data was divided into two categories: ‘Yes, I have a job’ (0) and ‘No, I do not have a job’ (1). Finally, the question concerning how long people had been living in Groningen needed to be recoded to binary data as well, as the current data was neither ordinal nor binary. Since the purpose of the question was to track the confidence and cycling experience in Groningen, the respondents’ answers were cut at the one-year mark: ‘0-1 year’ (0) and ‘more than one year’ (1). All questions, including how they have been coded, can be found in table 2. The column ‘recoded’ explains whether or not certain questions needed new categories and therefore needed to be recoded.

Table 2. The socio-demographic variables (recoded: yes/no; abbreviations in brackets)

QUESTION	RECODED	CATEGORIES
What is your gender? (GENDER)	No	0 = Male
		1 = Female
What type of degree are you following? (DEGREE)	Yes	0 = Bachelor
		1 = Master / PhD
What is your age? (AGE)	No	N/A
What is your nationality? (NATIONALITY)	No	0 = Dutch
		1 = Non-Dutch
How long have you been living in Groningen? (GRONINGEN)	Yes	0 = 0 – 1 year
		1 = More than 1 year
Are you currently employed? (EMPLOYED)	Yes	0 = Yes
		1 = No

3.3.2 Descriptive Data Analysis

In this section, the representativeness of the data will be analysed. Representativeness of a dataset is important as it allows for more general statements about the entire population, rather than about the sample only. In this case, due to a lack of data concerning students in Groningen, especially those studying at the Hanze, it is sometimes hard to show the exact numbers and characteristics of the student population in Groningen. Table 3 shows the descriptive data regarding this study.

Table 3. Descriptive data including gender, age and nationality

	Results from sample
Gender (N=223)	
Male	104 (46.6%)
Female	113 (50.7%)
Other	6 (2.7%)
Average age (N=191)	22.59
Nationality (N = 223)	
Dutch	145 (65%)
Non-Dutch	78 (35%)

When considering gender, in 2018 CBS reported that the municipality of Groningen had 91 men per 100 women between 20 and 25 years old (CBS, 2018). This is comparable with the collected dataset, as this contains 90.6 men per 100 women between 20 and 25. When looking at the total proportion of men and women in the entire sample, there are 92 men per 100 women. This suggests that the measure used by the CBS is representative. Looking at age, 191 respondents out of 223 respondents answered the question resulting in a mean age of 22.59 with a standard deviation of 3.28. The distribution can be seen in figure 2, and the data are fairly normally distributed with a minor skew to the right. Finally, when looking at the respondents' nationality, it can be concluded that 65% are Dutch, while 35% have another nationality. Although the exact percentage of international students in Groningen is unknown, a rough estimate does give us an idea of the share of international students. Considering the data retrieved from the University of Groningen (2022) and the Hanzehogeschool (2020), around 20% of students in Groningen are international students. This means that the dataset used in this research has a large overrepresentation of international students, which is something to take into account when discussing and analysing the results.

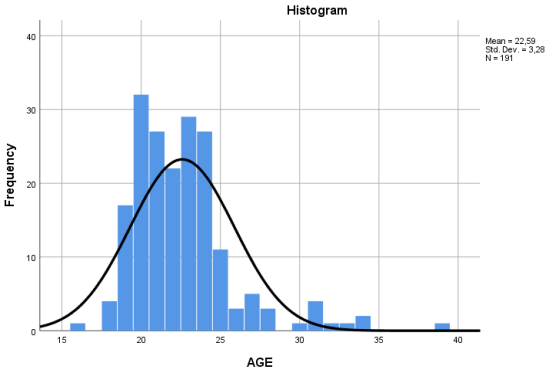
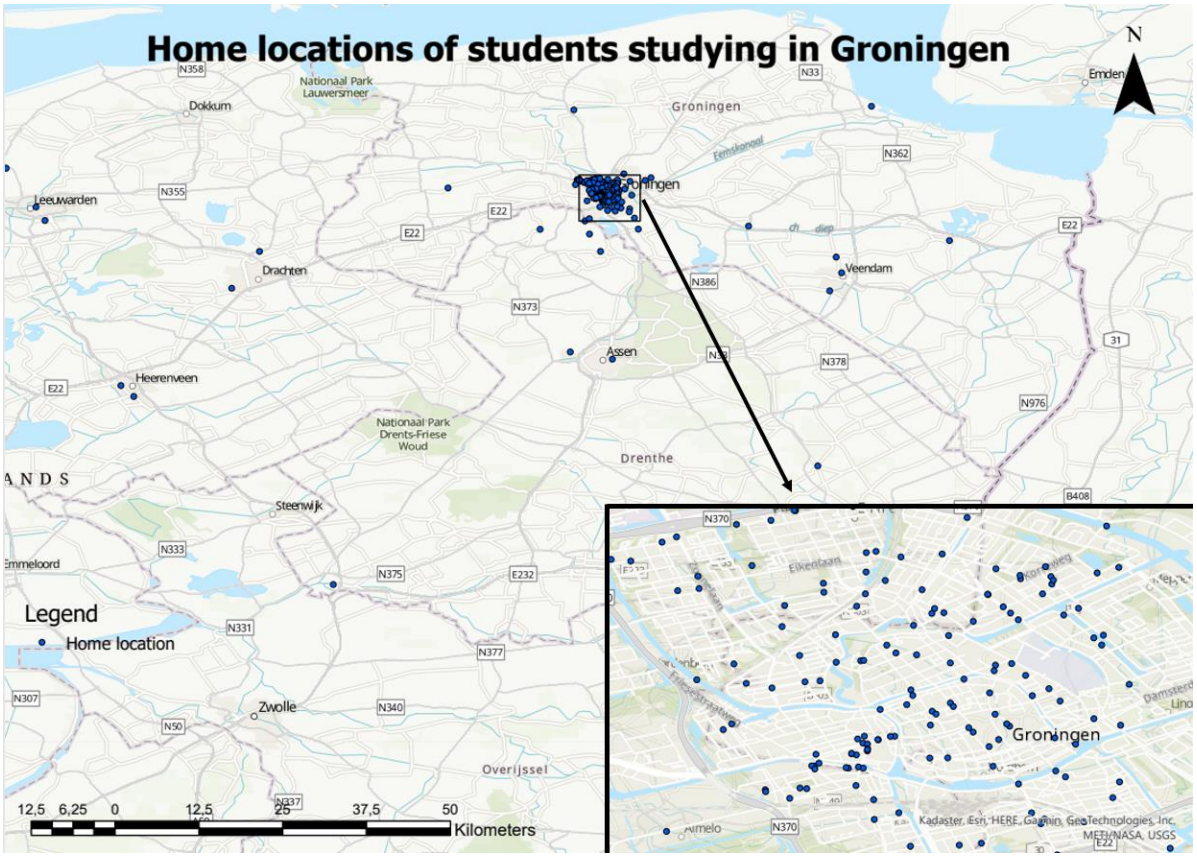
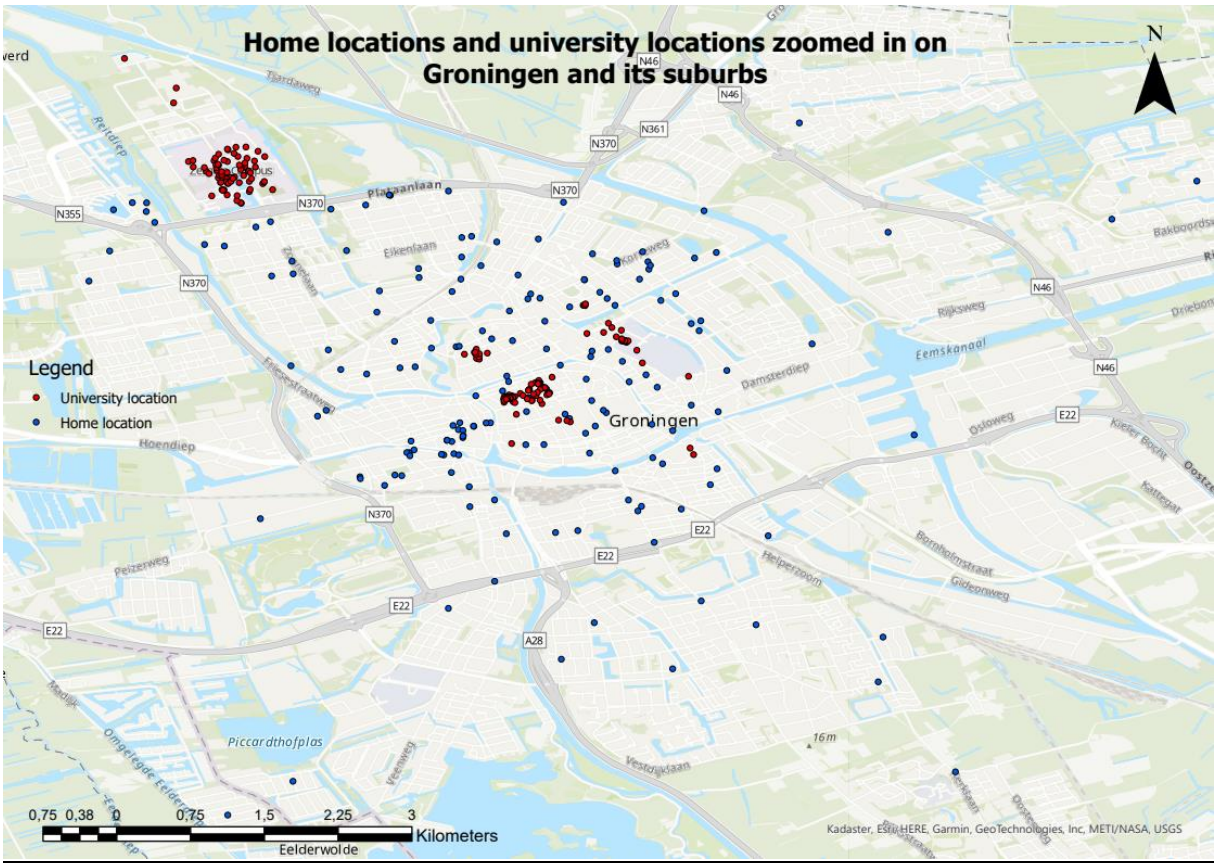


Figure 2. Histogram showing the distribution of age in the sample

Finally, it is also important to show the respondents' home location and the respondents' university location. An overview of these locations can be found in maps 1 and 2. The home locations are spread out over the city centre with only a handful living outside of the city of Groningen. This is shown in map 1. When it comes to the university locations, these are more clustered: there is one main cluster at the Zernike Campus, in the North of Groningen, and two clusters in the city centre, the Harmony building and Academy building (see map 2).



Map 1. Home locations of students studying in Groningen



Map 2. Home locations and university locations of students studying in Groningen zoomed in on Groningen and its suburbs

3.3.3 Statistical Analysis

With the raw data carefully transformed into data to be used in and compatible for SPSS, the analysis process will be discussed. In the results section, the four sub-questions will be discussed and answered. Before that, however, factor analysis will be performed to create so-called latent variables for both the built environment as well as the attitudinal factors. Factor analysis is used because the answers to the questions related to both factors show high correlation. Factor analysis is a technique that takes care of these correlations and is able to condense information from the different questions into a limited number of latent variables.

After the factor analysis, the sub-questions will be analysed and answered. Three of the four sub-questions look at the effect of different variables on the mode of transport. To answer these three questions, binary logistic regression has been used. More specifically, this method has been used to determine the effect of the built environment, attitudinal factors and socio-demographic factors on the mode of transport choice among students in Groningen. In the regression model, mode of transport is the dependent variable, while nationality and the new latent variables measuring attitudinal factors and built environment are the independent variables.

When performing the binary logistic regression, the stepwise regression method has been applied. With this method, variables are added in a specific order (Field, 2013). The research starts with adding

the socio-demographic factors and the variable measuring distance as the control variables. The socio-demographic factors are added first since they have the most influence on travel behaviour according to e.g. Xing et al. (2008) and Cervero & Kockelman (1997). Distance was controlled for as it can be an factor when separating short distance modes such as walking and cycling, from long-distance modes such as driving a car and public transport. Therefore, even though distance can be seen as an objective built environment factor, it has already been added in step 1 of the stepwise regression model. Next, variables that were not significant in step 1 were removed from the regression in the next steps, so that only the significant variables are left. Finally, nationality, the latent attitudinal factors and the latent built environment factors were added step by step (Bagley & Mokhtarian, 2002). Even though nationality is a socio-demographic factor, it has been added separately from the other socio-demographic factors as it covers a specific sub-question.

Table 4. Students' mode of transport choice when travelling to the university

	Frequency	*Percent*
Walking	32	14.3%
Cycling	159	71.3%
Public transport	29	13.0%
Driving	2	0.9%
Other	1	0.4%
Total	223	100%

Next, the modes of transport have been transformed into binary data in order to perform binary logistic regression. A multinomial logistic regression would also have been possible, but as there were not enough cases for each mode of transport this was not ideal (table 4). Making the 'mode of transport to university' question binary meant that modes of transport had to be combined. This has been done in three different ways; the descriptive statistics for each category division can be found in table 5. 'Cycling vs non-cycling' has been created as Groningen is a very bike-oriented city. However, the difference between walking and the other two non-cycling modes of transport is interesting as well. First of all, walking is climate-friendly while public transport and especially driving are not. Next to that, the factors that influence walking are different from the factors influencing car and public transport but more similar to cycling. Walking and cycling are therefore often being combined into one category, classified as non-motorised modes of transport (e.g. Bhat & Sardesai, 2006; Kuppam et al., 1999). Two other comparisons are therefore made. One comparison looks at the difference between active modes of transport (cycling and walking) and passive modes of transport (car and public transport). The other comparison looks at the difference between cycling and passive modes of transport. The difference between those comparisons is the inclusion of walking in the first category, which shows the effect of walking.

Table 5. The three different combined categories in binary data

	Frequency	*Percent*
Cycling vs non-cycling (total)		
Non-cycling	64	28.7%
Cycling	159	71.3%
Total	223	100%
Active MoT vs passive MoT (total)		
Passive MoT (public transport and driving)	32	14.3%
Active MoT (walking and cycling)	191	85.7%
Total	223	100%
Cycling vs passive MoT		
Passive MoT (public transport and driving)	32	25.8%
Cycling	159	74.2%
Valid Total	191	100%
Walking (excluded for this categorisation)	32	

The final sub-question that has to be discussed is the comparison between the perceived built environment and the objective built environment. To analyse this, a two-sample T-test will be used to find out whether there is a significant difference between the perceptions of the built environment at different university locations (Burt et al., 2009). As it concerns the built environment, two different locations need to be compared to give an idea of the difference in built environment. After the SPSS analysis, the results will be compared with the objective built environment, to see whether the subjective built environment agrees with the objective built environment. In table 6, the descriptive statistics of students' university locations can be found. There are three locations that host by far the most students. These locations are the Zernike Campus (N = 84), the Academy building (N = 46) and the Harmony building (N = 46). As the Harmony building and the Academy building are very close to each other (less than 100 meters), these locations will be combined in order to get a more representative and trustworthy idea of the difference between the perceived built environment and the objective built environment (as every category has more cases). This category will be called 'city centre'. This makes the total cases for this specific sub-question 176 out of 223, meaning that 79% of the data sample is used. The results section of this study shows how the two-sample T-test has been executed.

Table 6. Descriptive statistics of students' university locations

	Frequency	*Percent*
Zernike Campus	84	37.7%
Academy building	46	20.6%
Minerva Praediniussingel	1	0.4%
Harmony building	46	20.6%
Heymans building	10	4.5%
Wiebenga	6	2.7%
Prins Claus Conservatory	2	0.9%
UMCG (East side, main entrance)	4	1.8%
UMCG (West side)	15	6.7%
Minerva Zuiderdiep	1	0.4%
Other	8	3.6%
Total	223	100%

4. Results

4.1 Descriptive Statistics Regarding Travel Behaviour

Before analysing the data, showing the results and answering the main question and sub-questions, this section will show some of the descriptive statistics concerning the travel behaviour of students when travelling to their university. As can be derived from table 7 the preferred mode of transport is cycling. Their preference for cycling in general is very comparable to the mode of transport used when travelling to their university. This means that students in Groningen do not really deviate from their preferred mode of transport when travelling to the university. Walking and public transport stay roughly at the same percentage, and cycling increases slightly. The main difference is that driving reduces from fifteen cases to only two. This could suggest poor parking facilities or high parking costs around Zernike Campus, which is plausible as cars are not allowed in the city centre of Groningen, reducing the probability of students going by car (Christensen et al., 2017; Poelman & Langeler, 2017). However, the main reason for this decrease is car ownership, as almost 80% claim to have no car at their disposal. Of the other 20%, most claim they can only use it one or two days per week.

Table 7. Descriptive statistics of the travel behaviour of students

	Frequency	*Percent*
Preferred MoT in general		
Walking	29	13.0%
Cycling	144	64.6%
Public transport	35	15.7%
Driving	15	0.9%
Total	223	100%
Preferred MoT in general for short distances		
Walking	101	45.3%
Cycling	117	52.5%
Public transport	2	0.9%
Driving	3	1.3%
Total	223	100%
MoT used when going to university		
Walking	32	14.3%
Cycling	159	71.3%
Public transport	29	13.0%
Driving	2	0.9%
Other	1	0.4%
Total	223	100%

4.2 Factor Analysis

Before the data analysis regarding the socio-demographic factors, the attitudinal factors and the built environment factors can be discussed, a factor analysis needed to be conducted. This is the case as some of the ordinal questions concerning the built environment might overlap. This will reduce the number of variables, and the remaining variables will be latent variables rather than observable variables (Beaumont, 2012; Field, 2013). A second factor analysis has been performed to create latent variables for the attitudinal variables. When doing a factor analysis, a scree plot in combination with a rotated component matrix helps to understand which variables can be accumulated into one new latent variable. The scree plot shows how many eigenvalues over 1 there are, while the rotated component matrix shows the factor scores that can be extracted for these latent variables in SPSS. When looking at the scree plot of the built environment factor analysis (figure 3), five components can be observed with an eigenvalue higher than 1. In the table below (table 8), the new latent variables can be found, including the questions they arose from. The fifth component only exists of one question (BE16) as it did not match any other variables and will therefore be discounted for the rest of this research.

The scree plot of the attitudinal factors is very similar to the one concerning built environment, but now with only four components (figure 4). All four components were based on at least two questions and were therefore all relevant for the research. In table 9 the new latent variables for the attitudinal factors can be found, including the questions on which they are based.

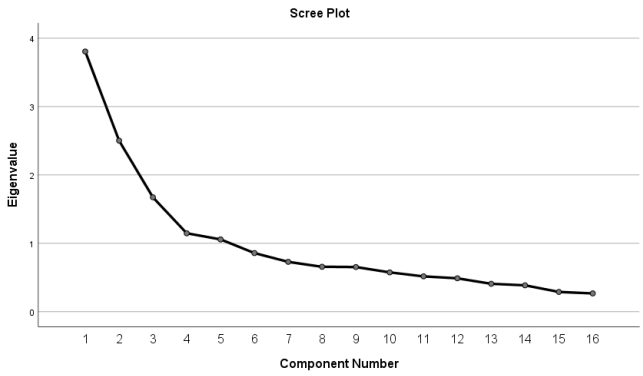


Figure 3. Scree plot of the built environment

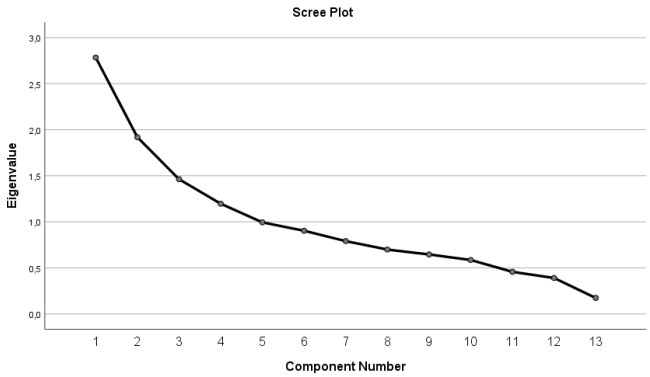


Figure 4. Scree plot of the attitudinal factors

Table 8. The latent variables of the perceived built environment

Latent variable	Percentage of explained variance	Maptionnaire question	Rotated factor loading
1. Bike facilities	23.78	BE5: The location is easily accessible by cycling	0.734
		BE6: It is safe to cycle to this location	0.791
		BE7: There are enough cycling paths to access the location	0.848
		BE8: The cycling paths make me feel safe	0.774
2. Spacious features	15.64	BE10: The location is easily accessible by car	0.636
		BE11: There are enough parking spots for cars around the location	0.634
		BE12: There are enough green spaces surrounding the location	0.699
		BE14: There are enough tree that offers shades on the pedestrian area	0.760
		BE15: There are enough benches at the location	0.567
3. Accessibility	10.46	BE1: The location is easily accessible by foot	0.736
		BE2: It is safe to walk to this place	0.539
		BE9: The location is easily accessible by public transport	-0.527
		BE13: There are enough amenities and facilities (such as stores, restaurants etc.) surrounding the location	0.459
4. Sidewalk and lighting	7.2	BE3: The sidewalk is wide enough	0.713
		BE4: There is enough lighting to make me feel safe	0.813
5. Architecture	6.6	BE16: There is a variety of architectural styles around the location	0.867

Table 9. The latent variables of the attitudinal factors

Latent variable	Percentage of explained variance	Maptionnaire question	Rotated factor loading
1. Pro passive transport	21.42	AF1: I feel like I should travel by car	0.547
		AF2: I feel like I should travel by public transport	0.707
		AF3: I feel like I should travel by bike	-0.780
		AF7: It is important for me that I can do other things while travelling (e.g. reading, being on my phone, etc.)	0.506
		AF11: Cycling to the university is too much effort for me	0.787
2. Walking obligation perception	14.76	AF4: I feel like I should travel by foot	0.852
		AF10: Walking to the university is too much effort for me	0.940
3. Costs and external factors	11.30	AF5: The weather influences the mode of transport I choose	0.565
		AF6: Waiting for a mode of transport while travelling annoys me	0.589
		AF12: The price of fuel and the price of parking affect my choice to travel by car	0.595
		AF13: The price to travel by public transport affect my choice to travel by public transport	0.514
4. Environment and safety	9.20	AF8: I think about the environment when choosing the mode of transport	0.805
		AF9: I think about safety when choosing the mode of transport	0.746

4.3 The Influence of Socio-Demographic Factors on Travel Behaviour

As mentioned earlier, the analysis of the data is carried out by using stepwise regression. This means adding variables stepwise into the regression model. With every step, the model should become stronger as the significant variables stay in the model, while the variables that are not significant are removed (Väliaho & Pekkonen, 2022). Steps 2, 3 and 4 answer a different sub-question, which means that each results section covers a different step and at the same time answers a different sub-question. The first step of this stepwise regression is adding all socio-demographic factors (control variables) such as age, gender, employment status, etc. Studies regarded the socio-demographic factors as influential to the travel behaviour sphere and therefore also to the mode of transport choice of individuals (Cervero & Kockelman, 1997; Xing et al., 2008). Although distance cannot be considered a socio-demographic variable, as was already explained in section 3.3.3, it is nonetheless an important control variable and therefore is part of the control variables (Næss, 2012).

Column 1 in table 10 show the model that results when adding the control variables into the regression model, with the mode of transport choice to university as the dependent variable. The results in column 1 have been dissected into cycling and non-cycling where the latter includes walking, public transport and driving a car. The alternative regression models can also be seen in this table (columns 2 and 3) but will be discussed later. In these models, the mode of transport choice will be divided into different categories (e.g. active vs passive modes of transport) to see how much the division of modes of transport matters.

Table 10. Step 1 of the stepwise regression. Socio-demographic variables added to the model

	Cycling vs non-cycling (column 1)		*Active MoT vs passive MoT (column 2)*		*Cycling vs passive MoT (column 3)*	
	Beta	Sig.	Beta	Sig.	Beta	Sig.
GENDER	-.026	.889	1.183	.206	1.160	.215
DISTANCE	-.166	.004	-.584	.001	-.562	.001
DEGREE	-.288	.567	.229	.856	.267	.832
AGE	-.039	.569	.283	.219	.269	.240
GRONINGEN	-.489	.303	-.298	.757	-.272	.777
EMPLOYED	-1.130	.011	-.022	.980	-.098	.913
CONSTANT	3.093	.055	-1.897	.693	-1.704	.723
Adjusted R^2	.328		.710		.704	

The results shown in column 1 of table, suggest that only two of the control variables are statistically significant, that is, the employment status ('employed': P (0.004) < 0.05) and the lateral distance from home to university ('distance': P (0.011) < 0.05). Both distance and employment make people less likely to cycle. The fact that when someone is employed is associated with a lower probability of travelling by bike is unexpected. One reason could be that those students are busier and therefore when travelling to the university, they rather go by public transport, so they can work on tasks while travelling. This claim is supported by Volosin (2014) who found in her research that those who were employed made fewer trips than those who were unemployed. The adjusted R^2 is 0.328, suggesting that the set of control variables only weakly predicts the dependent variable. The fact that a higher distance leads to a lower likelihood of someone cycling can be explained by the fact that it takes more effort to cycle when the distance increases. This corresponds with Dėdelė et al. (2020) and Cervero (2003) who found that short distances correspond with active modes of transport, i.e. cycling and walking, while longer distances are often related to passive modes of transport and specifically car use.

In columns 2 and 3 of table 10, the mode of transport choice is categorized differently. In column 2, the dependent variable is 1 if the mode of transport is cycling or walking, and 0 otherwise. In the column 3 column, the dependent variable is 1 if the mode of transport is cycling, and 0 if it is either travelling by bus or by car. As can be seen in table 10, using alternative ways of constructing the dependent variable changes the results when estimating a model only including the control variables compared to the results of table 10 presented above. The main difference is that when comparing cycling and non-cycling modes of transport two variables are significant, while in the other models only

'distance' is significant (P (.001) < 0.05). The unstandardized beta (B) of distance is very similar in both models (-.584 and -.562). However, when looking at the comparison between cycling and non-cycling, the unstandardized beta of 'distance' is lower compared to the other two models. This suggests that when the distance increases, students are more likely to use public transport to travel to the university rather than go by bike or by foot. As can be seen in table 10 as well, the category 'employed' is no longer significant in the two new models. When looking at the adjusted R^2 values, the two models in columns 2 and 3 show a much stronger fit than the model in column 1 comparing cycling with non-cycling modes of transport.

Table 11. Step 2 of the stepwise regression. Nationality variable added to the model

	Cycling vs non-cycling (column 1)		*Active MoT vs passive MoT (column 2)*		*Cycling vs passive MoT (column 3)*	
	Beta	Sig.	Beta	Sig.	Beta	Sig.
DISTANCE	-.173	.000	-.584	.000	-.563	.000
EMPLOYED	-.648	.093	N/A	N/A	N/A	N/A
NATIONALITY	-.117	.773	.874	.438	.817	.468
CONSTANT	2.078	.000	4.538	.000	4.409	.000
Adjusted R^2	.313		.758		.754	

Moving on to step 2, the model now only includes the significant socio-demographic control variables (as the insignificant socio-demographic variables are no longer relevant and will be left out from the next steps in the empirical analysis) and adds the nationality variable to the model. Although nationality is a socio-demographic, it is added separately, as the variable specifically refers to one of the sub-questions. The results of the analysis of this model can be seen in table 11. The table shows that nationality is not statistically significant as P (0.773) > 0.05. This means that nationality does not seem to influence the travel behaviour of students.

When looking at step 2 of the stepwise regression, categorizing the mode of transport differently leads to similar results (columns 2 and 3); 'employed' shows N/A for these categorisations as this variable was not significant in step 1. Here, the results for nationality are no different from the results of the comparison between cycling and non-cycling modes of transport. The nationality variable is still not significant for the model in column 2 and column 3 (P (0.438 & 0.468 respectively) > 0.05). Therefore, it can be concluded that nationality does not seem to significantly influence the mode of transport choice for a sample of students in Groningen. This is not in agreement with the findings of Haustein et al., (2019) and Buehler (2011).

4.4 The Influence of Attitudinal Factors on Travel Behaviour

As discussed in section 3.1.1, the 13 questions concerning attitudinal factors have been transformed into four new latent variables by doing a factor analysis. These four new variables can be found in table 9. In step 3 of the stepwise regression, these four latent variables are added to the variables that were shown to be significant in step 1 of the analysis. The four latent variables are added to the stepwise regression, as studies show that attitudinal factors influence travel behaviour more than the built

environment (Bagley & Mokhtarian, 2002). The results of the model including the attitudinal factors and the significant control variables 'distance' and 'employed' can be found in table 12 below. As can be derived from the table, three of the four latent variables are significant (P < 0.05). The adjusted R^2 value is 0.737, which indicates the model has a strong fit (Burt et al., 2009).

Table 12. Step 3 of the stepwise regression. Attitudinal factors added to the model

	Cycling vs non-cycling (column 1)		*Active MoT vs passive MoT (column 2)*		*Cycling vs passive MoT (column 3)*	
	Beta	Sig.	Beta	Sig.	Beta	Sig.
DISTANCE	-.440	.019	-.586	.024	1.160	.215
EMPLOYED	-.462	.412	N/A	N/A	N/A	N/A
PRO PASSIVE TRANSPORT	-2.039	.000	-3.789	.010	-4.625	.030
WALKING OBLIGATION PERCEPTION	2.101	.000	-1.417	.194	-0.86	.953
COSTS AND EXT. FACTORS	.001	.997	-.352	.173	-.471	.624
ENVIRONMENT AND SAFETY	-.616	.040	1.533	.238	2.116	.191
CONSTANT	3.571	.000	9.426	.010	10.034	.023
ADJUSTED R^2	.737		.940		.949	

'Passive transport mode focused' is one of the significant latent variables (P (.000) < 0.05). These results suggest that individuals rather travel by car or public transport than by bike as they find cycling too much of an effort. Their personal normative belief is to prefer both the car and public transport over cycling. This is in line with Koppelman & Lyon's analysis (1981). Although they did not include cycling in their analysis, they found bus and car to be very similar concerning the personal normative beliefs.

The second significant latent variable is 'walking obligation perception', referring to those individuals who feel they should walk but at the same time do not want to. This variable is associated positively with the choice of using the bike to go to the university (P (.000) < 0.05). This indicates that individuals may choose the bike instead of any other mode of transport, including walking. Next to that, distance and time may also play a role for someone who feels like they ought to walk to the university. One of the respondents claimed his/her favourite mode of transport is walking. However, even though this respondent lives a kilometre away, he/she often cycles to the university as he/she is in a hurry. The final significant latent variable is 'environment and safety' (P (.040) < 0.05). This result indicates that individuals may be very conscious of their decisions as they take into account the environment and their safety in the decision-making process. This latent variable has a negative unstandardized beta, meaning that these people most likely choose either walking or public transport instead of cycling. This result will be further discussed when comparing cycling, as well as active modes of transport, to passive modes of transport.

When looking at the variables that do not show any significance in the model in table 12 employment status stands out (P (.412) > 0.005), as this variable was significant in previous models. Because it is not significant in this model, this variable will not be included in later analyses when adding the latent variables related to the built environment in the model. The other variable to be discussed refers to 'costs and external factors' (P (.997) > 0.05), which are highly insignificant. According to many studies

(e.g. Cervero, 2002; Chen et al., 2008), this variable is of major influence on one's travel behaviour. However, when taking a closer look at the data it is evident that 214 out of the 223 (96% of the sample) respondents travel for free to their university. They either travel by foot, by bike, or they have a Dutch public transport card, which allows them to travel for free (Government of the Netherlands, 2021). The average costs for the remaining nine respondents are 3.38 euros per trip to the university. Considering that 96% of the respondents travel for free to their university, it can be concluded that costs are not a determining factor when it comes to the students' choice of mode of transport.

In order to further elaborate on the influence of attitudinal factors of students on their travel behaviour, active modes of transport including cycling are compared to passive modes of transport. The difference between those two comparisons can then be seen as the significance of walking when it comes to the attitudinal factors. Again, two alternative dependent variables are constructed. In column 2 of table 12, the dependent variable is 1 if the mode of transport is cycling or walking, and 0 otherwise. On the column 3 of table 12 the dependent variable is 1 if the mode of transport is cycling, and 0 if it is either travelling by bus or by car.

The 'passive transport mode focused' category remains significant in the regression models shown in column 2 and in column 3 in table 12. The unstandardized beta has an even stronger negative value than in the comparison between cycling and non-cycling modes of transport. This further supports the argument made before that students who have this preference tend to cycle less. Besides that, distance has a significance level of $P < 0.05$ in the model in column 2 and $P > 0.10$ in the model in column 3, meaning that distance becomes less of an issue when taking walking out of the equation. This can be explained by the fact that, as can be seen in map 1, most respondents live in the city of Groningen, and therefore the distance from home to university is often both doable by bike and by public transport.

The results in table 12 also show that the latent variable 'environment and safety' is not significant when categorizing the mode of transport differently, meaning the variable is only significant when comparing cycling with non-cycling. It can therefore not be concluded from these regression models, whether this group of students prefers walking or public transport instead of biking. To find this out, a two-sample T-test has been performed (see table 13), which calculates and compares the mean for both public transport and walking. Although the mean is higher for walking, which would suggest that those students who are conscious of their decisions are more likely to walk, the test was not significant (P (.128) > 0.05), and therefore no strong conclusions can be drawn regarding this specific latent attitudinal factor.

Table 13. Two-sample T-test comparing the mean for public transport and walking regarding the latent variable 'environment and safety

	MoT to university	*Mean*
Environment and safety	Public transport	-0.057
	Walking	0.361
Significance of test (2-tailed)	0.128	

4.5 The Influence of the Built Environment

Having added all control variables, socio-demographic variables and the attitudinal factors, in the fourth step of this stepwise regression the variables measuring the built environment are added to the model. In section 4.2 the results of the factor analysis were discussed (see table 8). Sixteen different questions in the Maptionnaire were converted into five different factors, of which four were used in the research. Table 14 shows the results of the regression model when performing step four. As in the previous sections, this section will also first discuss the results portrayed in column 1, which compares cycling and non-cycling modes of transport.

Table 14. Step 4 of the stepwise regression. Built environment factors added to the model

	Cycling vs non-cycling (column 1)		*Active MoT vs passive MoT (column 2)*		*Cycling vs passive MoT (column 3)*	
	Beta	Sig.	Beta	Sig.	Beta	Sig.
DISTANCE	-.770	.003	-.788	.002	-.777	.003
PRO PASSIVE TRANSPORT	-2.873	.000	N/A	N/A	N/A	N/A
WALKING OBLIGATION PERCEPTION	2.375	.000	N/A	N/A	N/A	N/A
ENVIRONMENT AND SAFETY	-.470	.143	N/A	N/A	N/A	N/A
BIKE FACILITIES	-.208	.520	.796	.073	.852	.064
SPACIOUS FEATURES	.201	.522	-1.077	.114	-1.160	.129
ACCESSIBILITY	-1.399	.006	.536	.327	.469	.394
SIDEWALK AND LIGHTING	.310	.288	.423	.302	.380	.353
CONSTANT	4.502	.000	6.276	.000	6.187	.000
ADJUSTED R^2	.778		.818		.817	

Starting off with the comparison between cycling and non-cycling modes of transport, 'distance' (P (.003) < 0.05), 'pro passive transport' (P (.000) < 0.05) and 'walking obligation perception' (P (.000) < 0.05) are all statistically significant, while 'environment and safety' is no longer significant. When looking at the added built environment factors it is clear that only one variable is significant, which is the accessibility variable (P (.006) < 0.05). This category is very much urban-focused as it concerns the walkability, it takes care of enough amenities and facilities, and relates to the accessibility by public transport. The unstandardized beta is negative here, which means that walking is the preferred mode of transport. All other built environment factors are not significant which is especially surprising considering Groningen is such a cycling city.

Just like in the previous two sections, two alternative dependent variables are constructed. In column 2 of table 14, the dependent variable is 1 if the mode of transport is cycling or walking, and 0 otherwise. In column 3 of table 14, the dependent variable is 1 if the mode of transport is cycling, and 0 if it is either travelling by bus or by car. When looking at the table, one of the first things that stands out is that multiple cells do not contain a value (N/A). The reason for this is that adding the built environment factors and the attitudinal factors in one model created problems for these specific categorizations. Due to the fact that there is a correlation between factors from the built environment and from the

attitudinal factors, the adjusted R^2 increased to a value of 1,000. The correlations that were found, and which are shown in table 15, do not have a great Pearson correlation value, and therefore this does not have to be a problem. This is, however, a problem when comparing cycling with passive modes of transport and active modes of transport with passive modes of transport, as the 'passive modes of transport' category has a considerably low number of cases (only 32 cases compared to the 64 when comparing cycling with non-cycling modes of transport). The low number of cases in itself is not a problem, as it is still more than 30 (Field, 2013). However, when combining a low number amount of cases with too many added variables, it does become a problem which explains an adjusted R^2 value of 1. Therefore, the built environment factors and the attitudinal factors have been kept separate throughout these analyses.

When looking at the data, only the 'bike' category is significant for both the models in column 2 and column 3 (P (.073 and .064 respectively) < 0.10). This category covers people who appreciate good cycling facilities as it covers the cycling safety, accessibility by bike, and cycling paths. The students who rated this high also tend to use active modes of transport. When comparing cycling with non-cycling modes of transport without the attitudinal factors added to the model as well, cycling facilities is significant and also results in students more likely to cycle to their university location. The table showing these statistics can be found below in table 16.

Table 15. Correlations between built environment factors and attitudinal factors

		BIKE	SPACIOUS FEATURES	ACCESS[a]	SWLIGHT[b]	PRO PASSIVE T[c]	WALKING OBL.[d]	COSTSEF[e]	ENVSAFETY[f]
BIKE FACILITIES	Pearson correlation	1	,000	,000	,000	-,438**	,065	,049	,083
	Sig. (2-tailed)		1,000	1,000	1,000	,000	,362	,496	,246
	N	206	206	206	206	199	199	199	199
SPACIOUS FEATURES	Pearson correlation	,000	1	,000	,000	-,054	,120	,167*	,116
	Sig. (2-tailed)	1,000		1,000	1,000	,450	,092	,018	,102
	N	206	206	206	206	199	199	199	199
ACCESS[a]	Pearson correlation	,000	,000	1	,000	-,209**	-,375**	-,018	,098
	Sig. (2-tailed)	1,000	1,000		1,000	,003	,000	,795	,170
	N	206	206	206	206	199	199	199	199
SWLIGHT[b]	Pearson correlation	,000	,000	,000	1	,076	-,072	-,082	-,030
	Sig. (2-tailed)	1,000	1,000	1,000		,288	,312	,252	,670
	N	206	206	206	206	199	199	199	199
PRO PASSIVE T[c]	Pearson correlation	-,438**	-,054	-,209**	,076	1	,000	,000	,000
	Sig. (2-tailed)	,000	,450	,003	,288		1,000	1,000	1,000
	N	199	199	199	199	212	212	212	212
WALKING OBL.[d]	Pearson correlation	,065	,120	-,375**	-,072	,000	1	,000	,000
	Sig. (2-tailed)	,362	,092	,000	,312	1,000		1,000	1,000
	N	199	199	199	199	212	212	212	212
COSTSEF[e]	Pearson correlation	,049	,167*	-,018	-,082	,000	,000	1	,000
	Sig. (2-tailed)	,496	,018	,795	,252	1,000	1,000		1,000
	N	199	199	199	199	212	212	212	212
ENVSAFETY[f]	Pearson correlation	,083	,116	,098	-,030	,000	,000	,000	1
	Sig. (2-tailed)	,246	,102	,170	,670	1,000	1,000	1,000	
	N	199	199	199	199	212	212	212	212

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

a: Accessibility b: Sidewalk and lighting c: Pro passive transport d: Walking obligation perception e: Costs an external factors f: Environment and safety

Table 16. Step 4 of the stepwise regression, without attitudinal factors. Concise version of SPSS output

	Cycling vs non-cycling	
	Beta	Sig.
DISTANCE	-.185	.002
BIKE FACILITIES	.549	.008
SPACIOUS FEATURES	.044	.824
ACCESSIBILITY	-.522	.018
SIDEWALK AND LIGHTING	.015	.939
CONSTANT	1.821	.000
ADJUSTED R^2	.778	

4.6 Comparing the Built Environment of University Locations

This section will focus on perceived built environment and objective built environment. The perceived built environment at the Zernike Campus and the city centre (Harmony building and Academy building) will be analysed and compared. Next, the perceived built environment score of each location will be compared to a description of the objective built environment to see whether the perceived built environment corresponds to the objective built environment. The perceived built environment score from the various will be calculated with a two-sample T-test. This analyses whether there is a significant difference between the two locations when it comes to the built environment factor scores (Burt et al., 2009). In table 17 the results of this two-sample T-test are shown.

Table 17. Results of two-sample T-test, university location as grouping value and the built environment factor variables as test variables

	University location	*Mean*	*Sig. (2-tailed)*
BIKE FACILITIES	Zernike Campus	.308	.001
	City centre	-.179	
SPACIOUS FEATURES	Zernike Campus	.259	.000
	City centre	-.291	
ACCESSIBILITY	Zernike Campus	.839	.000
	City centre	.727	
SIDEWALK AND LIGHTNING	Zernike Campus	1.14	.443
	City centre	.907	

When looking at the factors in table 17, the first three built environment factors are significant. The first built environment factor to be discussed is the bike facilities factor. This latent variable includes cycling accessibility, the safety of cycling and the quality of cycling paths around the university location. The difference in the mean is large and significant (P (.001) < 0.05), as the effect of this factor is positive

at Zernike Campus but negative in the university locations in the city centre. This means that the previously mentioned cycling facilities (accessibility, safety and cycling paths) are valued as more important around the Zernike Campus as compared to locations in the city centre. The difference in the mean of the university location, concerning the score of the perceived built environment, corresponds with the objective built environment. This may be the result of the quality of planning management by the municipality. In 2018, a campaign was finalised by the municipality of Groningen together with the Dutch public transport authorities to stimulate students to bike to the Zernike Campus (Groningen Bereikbaar, 2018). The campaign was called 'Smart Route'. Two separate routes consisting of wide cycling lanes (cycling highways) were built to allow cyclists to safely travel from the city centre to the Zernike Campus. On the cycling paths, cyclists are almost always disconnected from other parts of the roads and therefore are not disturbed by other modes of transport such as buses or cars. The lack of harmony between different modes of transport, as Arroyo et al. (2019) claim, is one of the reasons for people to not ride a bicycle. When comparing this to the city centre, there are no safe cycling paths to drive to the city centre and it is extremely busy, full of shopping pedestrians and cyclists (Sikkom, 2018). Most routes consist of busy crossings, narrow roads and certainly no separate cycling lanes. As there are no cycling lanes, this means a cyclist has to share the road with cars, vans and destination traffic such as large trucks. Taking everything into account, the Zernike Campus is more accessible by bike and should feel safer for cyclists, meaning the perceived built environment and objective built environment are in agreement. Whereas Ma & Dill (2015) claimed that perceived built environment cannot predict cycling preference, this study shows that perceived built environment can predict mode of transport after all.

The second built environment factor is the spacious features factor. The factor involves green spaces, accessibility by car, and parking spots for cars. Again, there is a rather large difference in the mean of the perceived built environment when comparing Zernike Campus with the city centre, including a clear significance level (P (.000) < 0.05). The mean value for the 'spacious feature' factor is positive at the Zernike Campus (.259), but negative in the city centre (-.291). Here, the perceived built environment compares well with the objective built environment as the spacious features correspond better to the Zernike Campus location than to the city centre. When looking at these spacious features around the university locations in the city centre, cars are only allowed in the city centre for very specific reasons, which means students are unlikely to commute to the university by car (Poelman & Langeler, 2017). The Zernike Campus does have car parking areas close by, although these are meant for staff rather than students. However, students can park for free just outside the Zernike Campus complex (Campus Groningen, 2022). As a comparison, the nearest parking garage to the university locations in the city centre cost 4 euros per hour (Gemeente Groningen, 2022). A comparison between the greenery at both locations can be seen in figure 5: the area around the Zernike Campus is much greener, and therefore the students' perceived built environment indeed corresponds with the objective built environment.

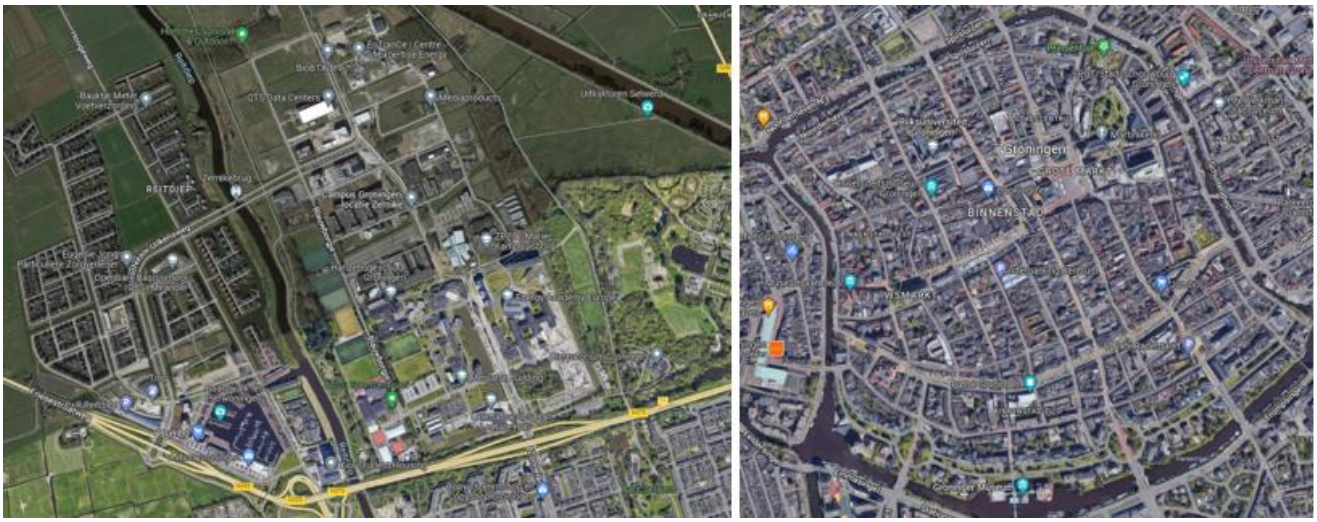


Figure 5. Overview of the greenery of the Zernike Campus (left) and the city centre (right). Screenshots taken from Google Maps

The final significant built environment factor (P (.000) < 0.05) is the accessibility factor. Although there is a significant difference between the two university locations, the mean for Zernike Campus is only a little bit higher compared to the locations in the city centre. Considering that the accessibility factor consists of accessibility by public transport, accessibility and safety for pedestrians, and the amenities surrounding the location, this does not entirely correspond to the objective built environment. The accessibility by public transport is indeed better at Zernike Campus, as there are multiple bus stops for several different bus lines. In the city centre, buses are barely allowed, and the closest bus stop to the university locations in the city centre is still a 300-meter walk (Qbuzz, 2022).

However, although the perceived accessibilty by public transport corresponds to the objective built environment, this is less definite for the other components of the accessibility factor. One of the characteristics of a city centre is that it is a centre for shopping and commerce. Although there are a few stores and restaurants at the Zernike Campus, it cannot be compared to the store/restaurant density of the city centre of Groningen. One of the reasons for this deviation between the perceived built environment and the objective built environment is the newly built food court at the Zernike campus. The food quality compared to previous alternatives and the fact that it is relatively new may cause a higher perceived built environment.

The final characteristics of accessibility are the accessibility and safety by foot. Accessibility by foot is objectively better around the university locations in the city centre. Population density is much higher than at the Zernike Campus (Allecijfers, 2021), and there are more walking paths and pedestrian areas in the city centre. When comparing safety at the Zernike Campus and the university locations in the city centre, the city centre is less safe as there is access traffic, cyclists, other pedestrians, and more chaos in general (Sikkom, 2018). At the Zernike Campus, the pedestrian area is separated and pedestrians do not share the road with other modes of transport, making the Zernike Campus a safer place.

Concluding, the accessibility factor shows the greatest difference between the perceived built environment and the objective built environment. Two out of the four components of the accessibility factor correspond to the objective built environment. The fourth and final built environment factor covers the sidewalks and lighting. However, this factor was not significant (P (.443) < 0.05), and therefore no conclusions can be drawn regarding the difference between the perceived and objective built environment.

5. Conclusion

5.1 Summary of the Research Findings and Discussion

This research looked at the travel behaviour of students. As this study focused on the students at universities in the city of Groningen, the following research question was developed: *What factors influence transportation mode choice among students in the city of Groningen?* Alongside the main research question, four sub-questions have been constructed to help answer the main research question. Three of the sub-questions concerned the nationality, attitudinal factors the built environment and how these factors influence travel behaviour. The final sub-question looked at the differences between the objective built environment and the perceived built environment.

Below, the results of the empirical analysis will be summarized and the answers to the four sub-questions will be discussed. After that, a new conceptual model will be created. This new model will be based on the outcomes of the empirical analysis and will only include the factors that significantly influence the travel behaviour of students in the city of Groningen.

5.1.1 What Built Environmental Factors Influence Transportation Mode Choice Among Students in the City of Groningen?

The first sub-question focused on the built environment and looked at its influence on the travel behaviour of students. This sub-question was formalized as follows: *What built environmental factors influence transportation mode choice among students in the city of Groningen?* The results, presented in section 4.5, showed that two of the latent variables were significant. The accessibility latent variable was significant when comparing cycling with non-cycling modes of transport and high accessibility led to more people walking and fewer people cycling to their university. The latent variable accessibility covered mostly the design dimension, the diversity dimension and the destination accessibility dimension of the built environment. The other latent variable was significant throughout all comparisons (when excluding the attitudinal factors from the model), which was the latent variable of bike facilities. The models (table 14 and table 15) show that this variable leads to more people cycling. The bike facilities variable covers safety and the quality of cycling paths and this, therefore, shows that the design dimension of the built environment has the most influence on the travel behaviour of students in Groningen.

Literature found that design and diversity are the main influencing factors when it comes to the travel behaviour of students (Mitra & Nash, 2018; Tracy et al., 2011). These studies showed that both design and density are found to have an influence on the travel behaviour of students. However, the findings of this study stated that destination accessibility also has an effect on the travel behaviour, since good local accessibility (accessibility by foot) as well as good regional accessibility (accessibility by public transport) both led to more students walking to their university. Next to that, diversity also caused students to walk more, which is in line with Cao et al. (2009) – this was found in the general literature, not only regarding students. At the same time, density seems to influence the travel behaviour of students less than the literature suggests (Tracy et al., 2011).

Although, as this research shows, the students in the city of Groningen are already granted favourable circumstances when travelling to their university, this does not mean there are no policy recommendations regarding this issue. The cycling facilities in the city of Groningen are of a high quality, but the municipality should not be complacent. It is of great importance to keep taking care of these cycling facilities. This means well-lit, wide and well-maintained cycling paths are crucial, as this was stated as an important factor for people to cycle to their university. Next to that, this research recommends the municipality to consider to build more cycling highways, also to other locations in Groningen, since this research showed that good cycling facilities had a positive effect on people choosing to cycle.

5.1.2 Do the Attitudinal Factors Influence Transportation Mode Choice Among Students in the City of Groningen?

The second sub-question concerned the attitudinal factors and to what extent those factors influence the travel behaviour of students in Groningen. The sub-question that belongs to this is: *Do the attitudinal factors influence transportation mode choice among students in the city of Groningen?* Three of the four latent variables regarding attitudes were found significant. The pro passive transport latent variable was significant throughout all models, while the latent variables 'walking obligation perception' and 'environment and safety' were only significant when comparing cycling with non-cycling modes of transport (table 12). The significant latent variables mainly covered attitudes regarding beliefs, convenience, safety and environmental attitudes.

When looking back at the literature, the environmental attitude findings partly agree with the existing literature. This literature found that a pro-environmental attitude leads to an increase in the use of non-motorised modes of transport (Bagley and Mokhtarian, 2002; Eriksson, 2008) and specifically a decrease in car usage. The findings of this research show a specific preference for people with a pro-environmental attitude towards walking. The underrepresentation of the car as the mode of transport (N = 2), did not allow to control for car use regarding environmental attitudes. Regarding safety, Arroyo et al. (2019) found less safety leading to less use of active modes of transport. The findings of this research seem to partially support their statement as people who are more conscious of safety will prefer walking. Both beliefs and comfort were supported by two different latent variables ('pro passive transport' and 'walking obligation perception') and beliefs and comfort seem to be interlinked as well. People who believe they ought to travel by passive modes of transport, also value comfortability higher and are less willing to make an effort when travelling to their university location.

Next, this research found costs to have no influence on the mode of transport choice of students in Groningen. This is due to the fact that 96% of the respondents stated that they travel for free to their university (either by bike, foot or public transport). This is not in agreement with the findings by (Etminani-Ghasrodashti et al., 2018; Mohammed & Shakir, 2013). Given the specific conditions in Groningen, that is, students choose modes of transport that bear no costs, this finding can be explained. However, travel time (which is measured in travel distance in this research due to limited data resources) does have an influence on the travel behaviour as it was significant throughout the model in which more travel distance led to fewer people travelling by bike.

Regarding possible policy implications, the municipality of Groningen stated it has to cut down its expenses regarding buses, meaning some that bus lines may be less frequent in the near future (Venema, 2022). This research however shows that public transport is important for specific groups of the student population (table 14). Therefore, this study recommends the municipality not to cut down the expenses regarding buses from and to the university.

5.1.3 Is there a Difference Between Dutch Students and International Students with Respect to Transportation Mode Choice?

As there is a clear cycling culture in the Netherlands, the third sub-question looked at the difference in travel behaviour between nationalities: *Is there a difference between Dutch students and international students with respect to transportation mode choice?* As the study area was Groningen, a city located in the Netherlands, the nationality variable was categorized by comparing Dutch students with non-Dutch students. The result showed no significance regarding the nationality variable, meaning there is no difference in travel behaviour between Dutch and non-Dutch students in the city of Groningen. According to the existing literature, due to the cycling culture in a country, nationality also plays a role in the willingness to cycle in each country (Buehler, 2011; Government of the Netherlands, 2018). However, this study did not find significant impact of nationality, which suggests that international students adapt quickly to the Dutch cycling culture.

The results of this study also show that none of the other socio-demographic factors seem to play a role with regards to the travel behaviour of students in the city of Groningen. Research concerning these factors mostly showed the difference between men and women when it comes to cycling to their destination (Arroyo et al., 2019; Buehler (2011); Mitra & Nash, 2018). However, this research found no significance regarding gender. This may be explained by the fact that for women in the city of Groningen it is more normal to cycle due to the cycling culture in the Netherlands (Holligan, 2013; Van der Zee, 2015).

5.1.4 Do the Perceived Built Environment and the Objective Built Environment Influence Transportation Mode Choice Among Students in the City of Groningen and Is there a Difference?

Whereas the previous three sub-questions were very much related to each other as they were all part of the stepwise regression model, answering the final sub-question had a different set-up. The final sub-question looked at the difference between the perceived built environment and the objective built environment which resulted in the following sub-question: *Do the perceived built environment and the objective built environment influence transportation mode choice among students in the city of Groningen and is there a difference?* The results in section 4.6 showed that three out of the four latent variables regarding the built environment were significant. The objective built environment is mostly in agreement with the perceived built environment, when comparing the Zernike Campus with the university locations in the city centre. This does not correspond with Ma & Dill (2015) who found that perceived built environment is not able to predict the mode of transport choice. In this study there

was no difference between the perceived built environment and the objective built environment regarding the bike facilities and spacious features, but there was a difference regarding the accessibility latent variable. This variable covers both the design dimension and the destination availability dimension. However, the bike facilities and the spacious features variables both cover design. Since these latent variables were perceived according to the objective built environment, it can be concluded that there is only a difference between the objective built environment and the perceived built environment regarding the destination availability dimension.

5.1.5 New Conceptual Model

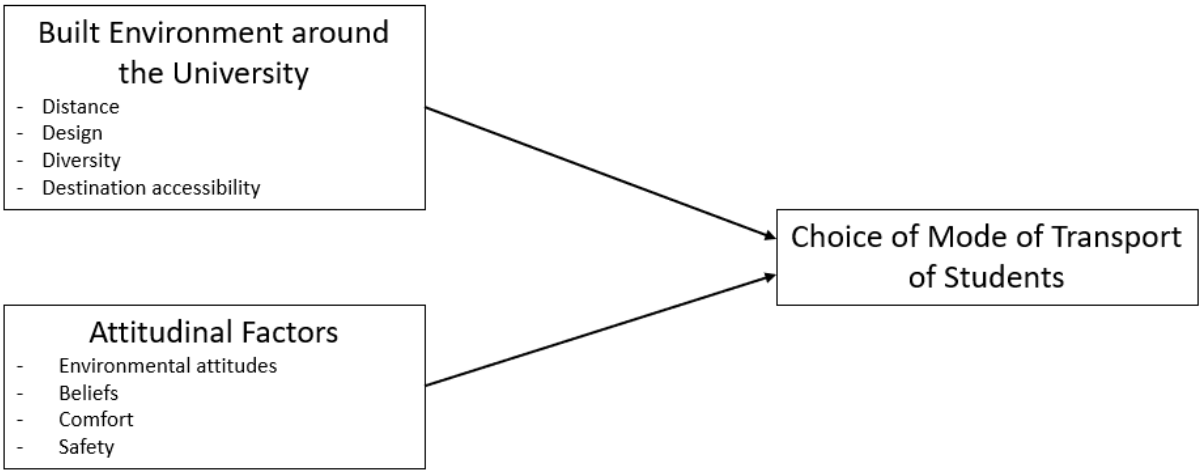


Figure 6. Adapted conceptual model based on the findings of the research

Considering all the findings discussed in the previous paragraphs, a new conceptual model has been constructed. It is based on the findings and concerns of the students in the city of Groningen in particular. The new conceptual model can be found in figure 6. As this research found the role of socio-demographic factors and travel costs to be insignificant these are no longer part of the conceptual model. The built environment around the university is more specified as the four dimensions depicted in figure 6, have the most influence.

5.2 Strengths and Limitations

One of the main strengths of this research is the representative dataset regarding the students in the city of Groningen. In total 223 respondents have been collected by performing different sample techniques at different locations and times in the city of Groningen. This ensured that the most important socio-demographic characteristics of the population (age, gender and nationality) were well represented in the dataset (see section 3.3.2). At the same time, as it is a sample and therefore only a small part of the population, it will never be completely representative. Some of the subgroups regarding students were underrepresented in the research of which one is PhD students. As there were only a few PhD students (N = 2) among the respondents, no statements could be made regarding this subgroup. Next to that, the same was the case for the group of students that travel by car to the

university (N = 2). A larger dataset could have included more students driving by car. This would have allowed for an analysis of the choices of mode of transportation made by this group of students.

Moreover, this research took multiple different factors into account that may influence the travel behaviour of students, while most studies focus on one specific factor of influence. Cervero and Ewing (2010) only looked at the built environment, while e.g. Kuppam et al. (1991) solely focused on the role of attitudinal factors regarding travel behaviour. It is important to note that although focussing on one specific factor may have advantages, it does not tell the full story. Getting the full picture is more likely when looking at the case study from multiple different angles (built environment, attitudinal factors and socio-demographic factors).

However, every study also has its limitations and this study is no different. First of all, the method used to compare the objective built environment and the perceived built environment has some flaws. Due to lack of necessary data, the perceived built environment and the objective built environment could not be analysed with the help of GIS. By doing so, the density at both university locations could have been based on numbers meaning this sub-question would not have been based on a descriptive analysis.

Finally, this study did not take into account the effect of scooters on the travel behaviour of students. Scooters in general, but also electric sharing scooters could have been considered as a mode of transport as this is an upcoming business in the city of Groningen and has its own space on the road. However, the scooter as a mode of transport has only been mentioned by three respondents, of which only one of the respondents answered 'other' when asking for the mode of transport they travel to the university with the most (assuming they meant scooter when answering 'other'). This shows that students do not seem to regularly use scooters as a mode of transport to travel to the university location.

5.3 Future Research

In the academic literature, several studies have investigated travel behaviour, but most of these studies focus on citizens of the working age. Less is published on the travel behaviour of younger age groups and students. More research focussing on the travel behaviour of younger age groups is needed, as this is an important and relatively mobile age group. This study shows what factors influence the travel behaviour of students in Groningen. The setting of this study is unique in terms of its spatial context. The Netherlands has a cycling culture, meaning that cycling is the predominant mode of transport. In other countries, cycling to the university may not be as dominant. Therefore a comparison showing the factors that influence the students' choices in different university cities may give interesting insights. When taking multiple university cities into account and looking at the travel behaviour of students, more general statements can be made regarding their travel behaviour. This study also looked at the travel behaviour of international students, but surprisingly found no significant difference in travel behaviour between Dutch and international students. Future research could focus on international students and study whether there is a difference between newly arrived and already settled international students. Hopefully the recommendations together with future research

suggestions will help regarding the mobility issue and will contribute to making the world a better place.

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7. Appendices

7.1 Appendix 1

Students' transportation mode choices to universities in Groningen

My name is Tom and I am currently finishing my master's degree *Society, Sustainability and Planning* at the Rijksuniversiteit of Groningen. For my master thesis, I am investigating factors influencing the choice of mode of transportation among students in Groningen and specifically how students travel to their University. The results of the study will hopefully provide insights for planners and policy makers to make the city of Groningen an even safer city and will lead to students travelling more comfortable to their university location.

If you are currently a student at one of the universities in Groningen I would be very grateful if you would take the time to complete this survey. It will only take a couple of minutes but will help me a lot with my research. Under the respondents, two Bol.com vouchers of 20 euros will also be given away.

Participation is voluntary

This survey is completely voluntary and your answers will be collected completely anonymously.

How will the data be used?

Your responses will be coded as numerical data which will be used in statistical analysis. The data will only be used for this research and can only be accessed by me and my supervisors. The data is analysed collectively and the results are published in my master's thesis.

If you have any questions, you can contact me via my university email at: t.hermes@student.rug.nl.

Introduction Questions

- What is your gender?
  - Male
  - Female
  - Other
  - Prefer not to say

- What is your age?

- What is your nationality?
  - Dutch
  - Other (please specify below)

- If you answered "other" at the previous question, please specify your nationality below (otherwise you can skip this question)

- At what location in Groningen do you study?
  - Zernike Campus
  - Academy building
  - Oude Kijk in ’t Jatstraat
  - Harmony building
  - Oude Boteringestraat
  - Wiebenga
  - Prins Claus Conservatory
  - UMCG (East side, main entrance)
  - UMCG (West side)
  - Minerva Zuiderdiep
  - Minerva Praediniussingel
  - Other (please specify below)

- If you answered "other" at the previous question, please specify your university location below (otherwise you can skip this question)

- What type of degree are you following?
  - Bachelor (Hanze, Stenden)
  - Bachelor (UG)
  - Master

- PhD

- Are you an exchange student? (I.e. are you here for a year or less and enrolled at a different university outside Groningen)
  - Yes
  - No

- How long have you been living in Groningen?
  - 0-6 months
  - 6 months - 1 year
  - 1-2 years
  - 2-3 years
  - More than 3 years
  - I don't live in Groningen

- Are you currently employed?
  - Yes, I work part-time
  - Yes, I work full-time
  - No

General travel questions

- Do you have any physical limitations that prevent you from using a specific mode of transport? If this is the case, please specify which modes of transport this includes. (Multiple answers are possible.)
  - No
  - Driving
  - Public transport
  - Cycling
  - Walking

- Do you own a bicycle?
  - Yes
  - No

- Do you have a driving license for a car?
  - Yes
  - No

- Do you have a car at your disposal?
  - Yes, almost always
  - Yes, most of the days in the week
  - Yes, but only 1 or 2 days per week
  - No

- Do you own a personal student “OV-chipkaart”?
  - Yes, this allows me to travel to university for free
  - Yes, this allows me to travel to university on a discount
  - No

- What mode of transport do you prefer in general?
  - Walking
  - Cycling
  - Public transport
  - Driving

- What mode of transport do you prefer in general in case of short distances?
  - Walking
  - Cycling
  - Public transport
  - Driving

Map questions

- Can you please pinpoint your home location on the map with the blue marker? For privacy reasons, you can pinpoint the intersection closest to your home.

- Can you please pinpoint the university location you commute to most often?

- What mode of transport do you use most often when travelling to your university?
  - Car
  - Public transport
  - Bike
  - Walking
  - Other

- What other modes of transport do you use when travelling to your university? Multiple answers are possible. If you always use the same mode of transport, please indicate this below
  - Car
  - Public transport
  - Bike
  - Walking
  - Other
  - I only use one mode of transport

Travel time and travel costs questions

- How long does it take to travel to your university by foot?
  - Less than 5 minutes
  - 5-10 minutes
  - 10-20 minutes
  - 20-30 minutes
  - 30-45 minutes
  - 45-60 minutes
  - More than 60 minutes

- How long does it take to travel to your university by bike?
  - Less than 5 minutes
  - 5-10 minutes
  - 10-20 minutes
  - 20-30 minutes
  - 30-45 minutes
  - 45-60 minutes
  - More than 60 minutes

- How long does it take to travel to your university by car?
  - Less than 5 minutes
  - 5-10 minutes
  - 10-20 minutes
  - 20-30 minutes
  - 30-45 minutes
  - 45-60 minutes
  - More than 60 minutes

- How long does it take to travel to your university by public transport?
  - Less than 5 minutes

- 5-10 minutes
- 10-20 minutes
- 20-30 minutes
- 30-45 minutes
- 45-60 minutes
- More than 60 minutes

- How much does travelling to your university cost you normally?
  - Free, I travel by foot
  - Free, I travel by bike
  - Free, I have a student OV-chipcard set on weekdays
  - It costs me money (please indicate below how much it costs you

- If travelling to the university normally costs you money, please specify how much this costs you normally in per trip & in euros (If it does not costs money, you can skip this question)

Built environment

The following questions are all about the environment around your university. Please indicate whether you agree or not with the statements. You can range your answers from strongly disagree (1) to strongly agree (5).

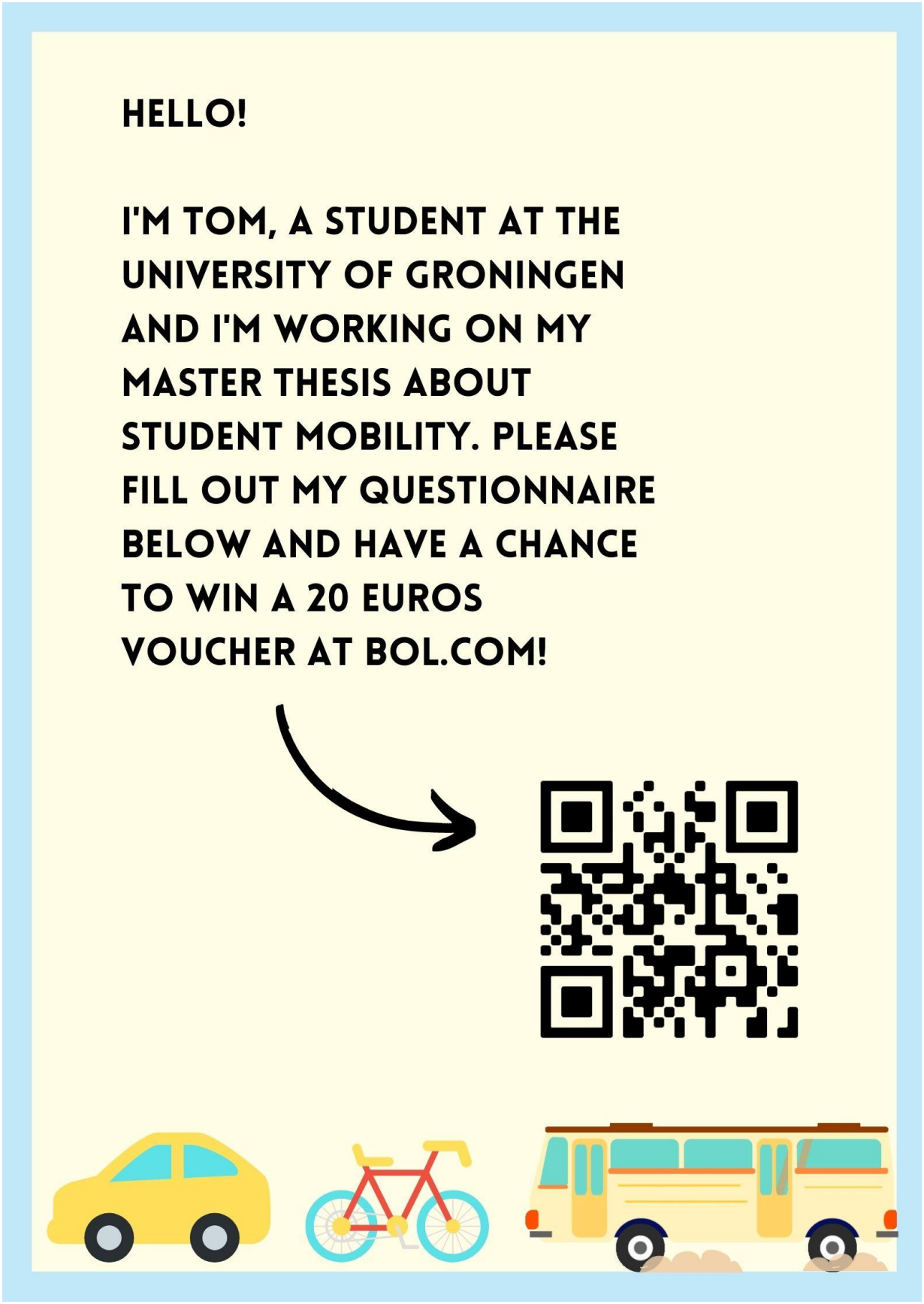
- The location is easily accessible by foot
- It is safe to walk to this location
- The sidewalk is wide enough
- There is enough lighting which makes me feel safe
- The location is easily accessible by bike
- It is safe to cycle to this location
- There are enough cycling paths to the location
- The cycling paths make me feel safe
- The location is easily accessible by public transport
- The location is easily accessible by car
- There are enough parking spots for cars around the location
- There are enough green spaces surrounding the location
- There are enough amenities and facilities (such as stores, restaurants etc.) surrounding the location
- There are enough trees that offer shade on the pedestrian area
- There are enough benches on the sidewalks around the location
- There is a variety of architectural styles around the location

Attitudinal factors

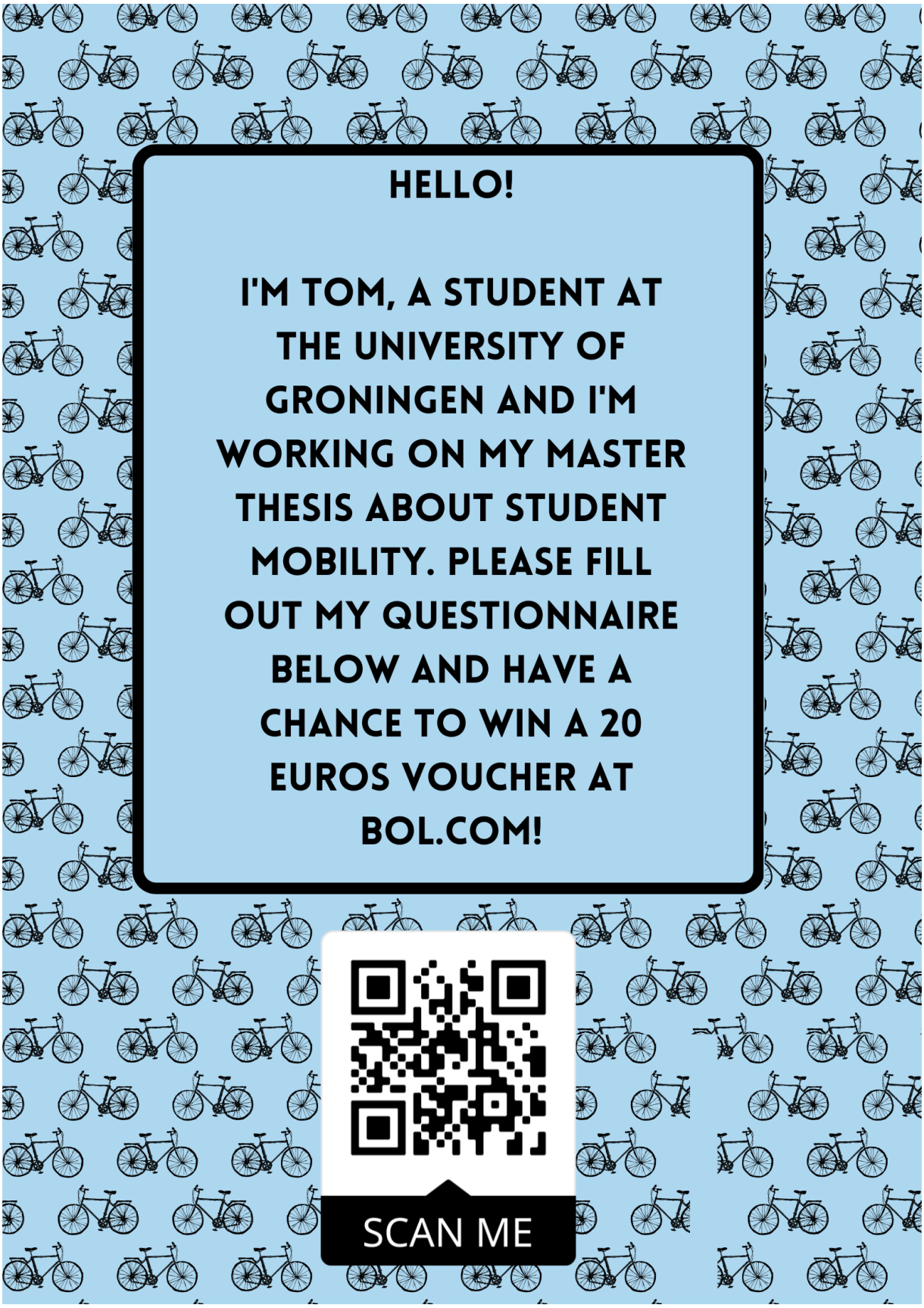
Please indicate whether you agree or not with the following statements. The answers range from strongly disagree (1) to strongly agree (5).

- I feel like I should travel by car to my university
- I feel like I should travel by public transport to my university
- I feel like I should travel by bike to my university
- I feel like I should travel by foot to my university
- The weather influences the mode of transport I choose
- Waiting while travelling annoys me
- It is important for me that I can do other things while travelling (e.g. reading, checking my phone etc.)
- I think about the environment when choosing the mode of transport
- I think about safety when choosing the mode of transport
- Walking to the university is too much effort for me
- Cycling to the university is too much effort for me
- The price of fuel and parking affects my choice to travel by car
- The price to travel by public transport affects my choice to travel by public transport

7.2 Appendix 2



7.3 Appendix 3



7.4 Appendix 4