university of groningen / faculty of spatial sciences

Bachelor Thesis

Perceived Built Environment, Perceived Cycling Accessibility and Travel Satisfaction by Bike among Students in Groningen

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Abstract

This study explores the relationship between perceived built environment, perceived accessibility and travel satisfaction among students in Groningen. A theoretical model was developed, supported by literature review to investigate the influence of perceived built environment and accessibility on travel satisfaction by bike. Empirical data were collected through surveys and analyzed using statistical tests. The findings confirm a direct relationship between perceived built area, perceived accessibility and travel satisfaction. Both perceived accessibility and perceived built environment showed a significant positive moderate correlation with travel satisfaction. The study concludes that the perception of the built area and accessibility to different facilities plays a significant role in determining satisfaction with travel by bike. Additionally, given the significant impact of perceived cycling infrastructure within the built environment on travel satisfaction and accessibility to facilities, prioritizing development of safe and convenient cycling infrastructure becomes crucial for urban planners and policymakers in practice.

Keywords: Groningen; students; perceived built environment; perceived cycling accessibility; travel satisfaction

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1. Introduction

The number of students in the Netherlands has been increasing exponentially in the past years. From the year 2020-2021 there has been a student population growth of 8 % (VSNU, n.d.). Such a trend from recent years is expected to continue to increase in the coming futures (Logo Ministerie van Onderwijs, 2017). With 25% of its population being students, Groningen has the highest student density in the Netherlands and appears to be where this population rise is most noticeable (Groningen.nl, n.d.). Groningen, despite being a small city, has become a vibrant university area with a diversified student community. However, this growth potentially raises concerns about the quality of life for students.

Although quality of life is very broad as a concept, one of the key domains that is thought to reflect quality of life and well-being is travel satisfaction (Lättman, Olsson and Friman, 2018; Ettema et al., 2011). Considering the daily travel of students in Groningen, for the majority it involves the bike as their main transport mode given the cultural popularity of it in the whole Netherlands. The daily commute by bike for students often involves attending classes, studying centers, libraries and recreational areas. The perceived accessibility to these different facilities plays a crucial role in their daily lives and potentially to their travel satisfaction when biking. Moreover, Echiburú, Hurtubia and Muñoz (2021) claim that in addition to the mode of transport chosen, the route also affects how satisfied one feels when traveling, suggesting that there is a relation between the built environment and travel satisfaction. Therefore this indicates that investigating connections between travel satisfaction and other variables (such built environment and accessibility) that might impact it, would entail benefits in improving student's quality of life in general and well-being based on these factors. Furthermore, understanding the relationship between travel satisfaction, perceived built environment and perceived accessibility, can provide a valuable insight for policymakers and urban planners to enhance transportation systems or services that better meet students needs.

The impact that the built environment has on life satisfaction is very straightforward. Aside from the objective attributes of the built environment, people's perception of the environment also has an influence on the quality of life (Zhou, Tan and Watanabe, 2021). Zhang and Zhang (2017) in their study discovered that perceived neighborhood environment qualities were positively related to life satisfaction. Based on current studies on perceived built area, and given that travel satisfaction is also considered as a component of life satisfaction, we would assume that perceived built environment would also potentially impact travel satisfaction. According to a recent study by Hu, Sobhani and Ettema (2023), where they explored the impact that travel mode has on travel satisfaction, the level of travel satisfaction was significantly associated with perception of the environment. However, to the best of the author's knowledge of this paper, there is a scarcity of studies further exploring the direct relationship between perceived built area and satisfaction of daily travel.

Moreover, it has been established that accessibility is positively connected to well-being (Lättman, Olsson and Friman, 2018). However, few research have investigated perceived accessibility and its relationship with other factors such as travel satisfaction. According to the study of Lättman et al. (2019), perceived accessibility has shown to have a strong impact on satisfaction with travel and life satisfaction among elderly. Based on this study, levels of perceived accessibility have been shown to decrease with age. Nevertheless, there haven't been many studies on perceived accessibility and how it affects various groups of populations.

Considering the aforementioned statements, a few research gaps can be noted, which can be used as the impetus for this research. Given the limited exploration of perceived accessibility and built environment in relation with travel satisfaction, it is evident that the link between these factors has not been explicitly and simultaneously investigated in one study. Additionally, a more specific approach into population, such as for students has not yet been examined. Among the student population, there is a knowledge gap concerning the

relationship between perceived built environment, perceived accessibility and travel satisfaction. By integrating these two research gaps it leads to the motivation of this study.

1.5. Research Problem

The aim of this study is to explore the relationship between perceived built environment, perceived cycling accessibility and travel satisfaction by bike among students in Groningen. Considering the aim of this study, the following main question has been developed:

How and to what extent can perceived built environment and perceived cycling accessibility to facilities influence travel satisfaction by bike among students in Groningen?

Exploring the "*how*" aspect of the research question helps in gaining a deeper understanding of the specific factors that are responsible for the influence of perceived built environment and cycling accessibility on travel satisfaction. On the other hand, exploring the "*to what extent*" part of the research question aids in determining the degree to which these variables influence one another. By exploring both aspects of the research question, a more comprehensive understanding of the relationship between these variables can be achieved.

To answer the main question, the following three secondary questions have arised:
SQ 1: How and to what extent does perceived built environment (PBE) influence perceived cycling accessibility (PCA)?
SQ 2: How and to what extent does perceived built environment (PBE) influence travel satisfaction (TS) by bike?
SQ 3. How and to what extent does perceived cycling accessibility (PCA) influence travel satisfaction (TS) by bike?

2. Theoretical Framework

In this chapter, concepts relevant to the research are discussed and their intricate interrelationships are investigated. Moreover, a conceptual model is presented to visually demonstrate how the main variables (perceived built environment, perceived accessibility, travel satisfaction) and other relevant indicators are interconnected. As a result, this section mainly focuses on answering the "*how*" part for each secondary question by using academic literature to support its findings.

2.1. Travel satisfaction

According to Mouratidis, Ettema and Næss (2019), travel satisfaction (TS) varies based on travel mode. In this research since the majority of students use bicycles as their main travel mode, it will focus on travel satisfaction when cycling. Based on Calvey et al. (2015), we can define travel satisfaction when using the bicycle as the fulfillment of one's needs and pleasure derived when cycling. Factors that indicate travel satisfaction are related to mood or emotional wellbeing during traveling (Lättman et al., 2019). The more positive mood or emotional status experienced during traveling the higher the overall satisfaction would be. Moreover, according to Lättman et al. (2019), travel satisfaction evaluation in general can be affected by three components: *a cognitive evaluation* and *two affective evaluation*s (positive deactivation and positive activation). Cognitive evaluation assesses the overall experience of traveling if it is for instance low or high standard (Lättman et al., 2019; Friman et al., 2013). On the other hand, affective evaluations take into account the emotional arousability when traveling such as stress, enjoyment, tiredness, or relaxation experienced (Lättman et al., 2019; Friman et al., 2013).

2.2. Perceived built environment

The study of the built environment is divided into objective and perceived/subjective. The objective built environment concerns the physical characteristics of the environment (Nordin & Nakamura, 2020). In contrast, the perceived built environment (PBE) deals with individuals' perceptions of their surroundings (Delpino-Chamy & Pérez Albert, 2022). Compared to the objective measurements, the subjective approach is best used for examining individuals' perceived and subjective opinions of their surrounding environment (Delpino-Chamy & Pérez Albert, 2022; Liu, Yang, et al., 2022; Nordin & Nakamura, 2020). This approach is particularly relevant when considering travel satisfaction, which is heavily influenced by emotional experiences during travel. However, objective measurements may not capture the emotional aspects that contribute to the satisfaction of traveling. Hence to comprehend how the built environment affects travel satisfaction it's crucial to gather an individual's perspective, making the subjective approach more suitable.

The majority of the existing studies explored extensively the influence between PBE and travel behavior (Ma, Dill and Mohr, 2014; Ma and Cao, 2017; Brüchert, Quentin and Bolte, 2022). However, as mentioned in the *Introduction* section there is a scarcity of studies directly exploring the relationship between PBE to both travel satisfaction and perceived accessibility. To address this research gap, this study will comprehensively explore each indicator of PBE in relation with travel satisfaction and perceived accessibility. As inspired by the study of Blitz (2021), the research will focus specifically on characteristics that pertain to cycling with the PBE, including *perceived cycling infrastructure quality, traffic environment/traffic volume, and public space quality.* In this way a more cohesive understanding of the relationship between PBE, travel satisfaction and perceived accessibility can be enabled.

2.2.1. Perceived cycling infrastructure and its relationship with perceived accessibility and travel satisfaction

Cycling infrastructure is related to the *availability* and *condition of cycling facilities* (Blitz, 2021), such as cycle paths, biking racks for parking, and traffic lights. The perceived sufficiency of these cycling facilities leads to the use of bikes when doing activities (Gössling & McRae, 2022). This suggests that higher or positive perceived cycling infrastructure around the local area may contribute to increased perceived accessibility to facilities. Additionally, as high levels of perceived cycling infrastructure is associated with a high *feeling of safety* and *low stress* when biking (Berghoefer & Vollrath, 2022), it implies that it positively influences cycling satisfaction.

2.2.2. Perceived traffic volume and its relationship with perceived accessibility and travel satisfaction

The perceived traffic environment relates to local traffic volumes and the travel habits of people from the surrounding area (Blitz, 2021). According to Rivera Olsson & Elldér (2023), areas that accommodate mixed traffic involving cars and bicycles sharing street space tend to have higher accessibility, connectivity and safety rate for cyclists. However, according to Manton et al. (2016), there is a negative relationship between motorized traffic volume and cycling safety. With high motorized traffic volume there is a higher risk of accidents and collisions, which lowers people's perceptions of safety. Consequently, it implies that a higher motorized traffic volume would potentially serve as a major barrier to cycling. Nevertheless, the negative perception of safety caused by high traffic might also have a negative impact on how easily amenities are seen to be accessible when cycling. Moreover, as demonstrated by Hu, Sobhani and Ettema (2023), negative perception of traffic volume also negatively influences satisfaction when traveling.

2.2.3. Perceived public space quality and its relationship with perceived accessibility and travel satisfaction

Perceived public space quality (PPSQ) can be largely decided by the *aesthetic* and *pleasantness* given by the public area (Blitz, 2021). Positive evaluation of attractiveness is one of the important factors for pleasant travel (Müggenburg et al., 2022). Indicating that attractive local spaces can enhance traveling experience by making it more enjoyable and convenient. Other findings also suggest that high green spaces also correlate with higher travel satisfaction (Mouratidis et al., 2019; Dong et al., 2015). According to Willberg et al.(2023), travel environment quality plays an important role as people are more inclined to cycle in areas that are attractive, pleasant and safe. In addition, Müggenburg et al. (2022) highlight the significance of an attractive and pleasant travel environment which ultimately facilitates efficient access to destinations. Furthermore, a high PPSQ significantly increases travel satisfaction; the more pleasant and beautiful the area is perceived the higher the level of travel satisfaction (Hu, Sobhani and Ettema, 2023).

2.3. Perceived accessibility and its relationship with perceived built environment and travel satisfaction

Perceived accessibility refers to the individual's subjective experience of reaching preferred destinations and engaging in activities of choice (Friman et al., 2020; Jamei et al., 2022). Similarly, Lättman, Olsson and Friman (2018), referred to perceived accessibility based on the perception on how *easy* it is to access and use the built environment, and transportation system as well as access activity choices. With regard to the definitions, this indicates that the perceived built environment has a direct positive relationship with perceived accessibility. Nonetheless, perceived accessibility also has an impact on travel satisfaction (Lättman et al., 2019). Where it displays that a higher level of perceived accessibility (travel options, access to favored activities, ease of travel) improves travel satisfaction while a lower level of perceived accessibility reduces travel satisfaction (Lättman et al., 2019).

There are different methods of indicating perceived accessibility such as destination/activity focused, utility focused, modal focused, trip focused, etc (Jamei et al., 2022). However, with a focus on perceived accessibility to facilities an approach that is *destination or activity specific* is more appropriate to be used in this study. This approach looks into the ease of reaching specific facilities, and it aids in exploring how people perceive the accessibility of particular activity locations, combinations of different services, or either of the two, while taking into account a specific travel mode (Jamei et al., 2022).

2.4. Sociodemographic influence on travel satisfaction, perceived built environment and perceived accessibility

As travel satisfaction is assessed on subjective perspectives, it may also vary on a variety of personal factors. Since each person’s travel preferences and needs might differ across socio demographic factors (such as age, gender, household type, mode availability, etc) the satisfaction obtained when traveling also might reflect a variety of patterns (Chen et al., 2022). In addition, individual characteristics may also have an effect on subjective perception of the local environment (Blitz, 2021) and accessibility (Lättman et al., 2019). Hu, Sobhani and Ettema (2023) in their study highlighted that perception of the environment and travel satisfaction differ between genders. Moreover, according to Vitman-Schorr et al. (2017), factors such as age, gender and education may have an impact on how accessible an activity location is perceived by the individual. Nevertheless, according to a research by van der Vlugt et al. (2019) where the relationship between objective and subjective accessibility is explored, most of these sociodemographic characteristics don’t have a significant association with perceived accessibility.

2.5. Conceptual Model

By combining the factors that influence each of the main concepts (PBE, PA and TS) in this study, the following conceptual model is derived (see figure 1). The model shows the influence the concepts might have on one another based on the previous studies (see background and theoretical framework). It is expected that the TS is directly influenced by PBE and PA. Moreover, the PBE indirectly influences TS through PA. Furthermore, all three main variables are expected to be influenced by sociodemographic characteristics.

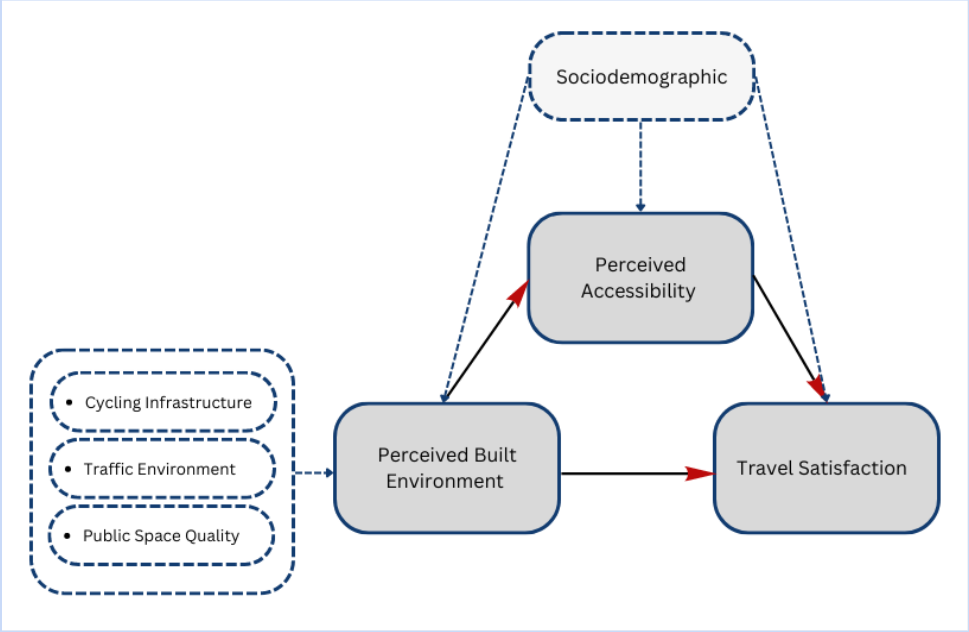

Figure 1: Conceptual model of this study

3. Hypotheses

The following hypotheses are identified based on the background, theoretical framework and conceptual model:

- *H1: **Positive** perception of built environment has a **positive** direct influence on perceived cycling accessibility*
- *H2: **Positive** perception of built environment has a **positive** direct influence on travel satisfaction by bike*
- *H3: **Positive** perception of cycling accessibility has a **positive** direct influence on travel satisfaction by bike*

4. Methodology

This research uses a single case study approach focused on Groningen. To answer the research of this case study a combination of methods was used. Firstly a comprehensive literature review was conducted to understand how PBE, PCA and TS influence each other, which served as the basis for the subsequent data collection method (a survey). Moreover, the study uses a quantitative approach because it's valuable when seeking to examine the degree of association between these variables.

4.1. Literature review

Since the main question of this research is to also understand how the PBE, PA and TS are interconnected, a literature review has also been conducted (see section 2). Various datasets, including Google Scholar,

SmartCat, Scopus, and Web of Science were used for the search of relevant academic literature. The search strategy employed appropriate keywords and search terms to identify studies that address the relationship between PBE, PA and TS.

4.2. Case study area: Groningen

Given the highest student population density in the Netherlands, Groningen is a suitable case study area for this research. Groningen is a small city with a size of 185.6 km square located in the north part of the Netherlands (City Population, 2023). Regarding the urban morphology, the city has an organic shape that characterizes it as a radial city (see figure 2). As the city promotes a sustainable way of traveling, the majority of citizens including students have adopted biking as their primary mode of transportation. Hence, making it appropriate for the research to specifically focus on cycling due to its popularity as a mode of transport among students.

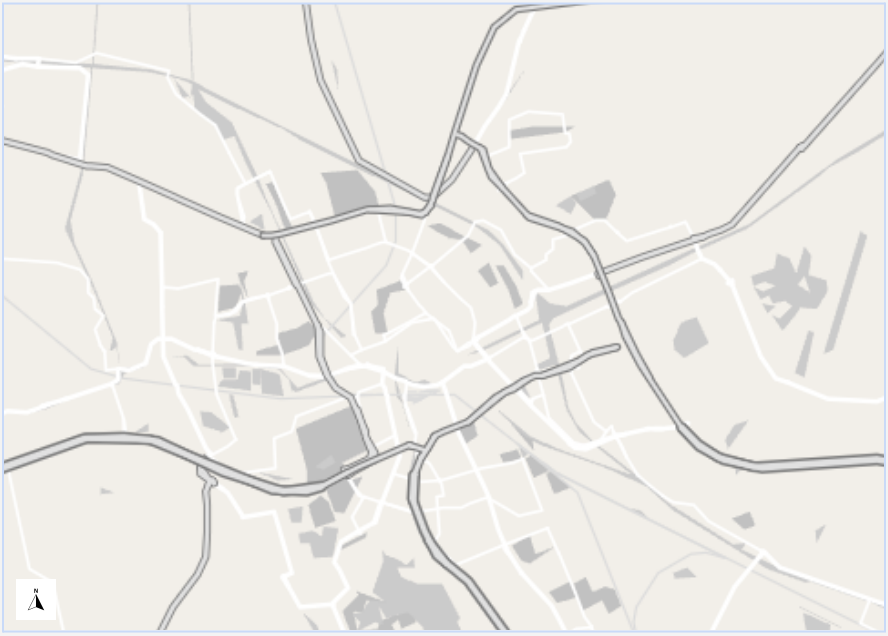

Figure 2: Groningen Landscape Map (Scribble Maps,.n.d)

4.3. Measurement tool

To collect data a survey was conducted. The survey consisted of a structured questionnaire which was divided into four parts. In the first part general socio-demographic data was collected such as age, gender, degree pursuing and nationality. In the second part data regarding perceived built environment was collected which is based on its main characteristics (perceived cycling infrastructure, perceived traffic volume and perceived public space quality). The third part focused on gathering data with an emphasis on perceived cycling accessibility to specific frequent services such as supermarkets, university campus (Zernike Campus), public spaces/green areas and hobbies. The fourth part focused on measuring travel satisfaction by bike based on cognitive quality evaluation (low standard vs. high standard), positive deactivation (boredom vs, enthusiasm) and positive activation (stress vs. relaxation) evaluations (Friman et al., 2013; Lättman et al., 2019). Perceived built environment and accessibility was measured through a unipolar 5 Likert scale ranging from (1) strongly disagree to (5) strongly agree. As for travel satisfaction, it was measured through a bipolar 7 Likert scale ranging from (1) extremely dissatisfied to (7) extremely satisfied. For a more complete overview of the survey see appendix 1-table 1a.

4.4. Sampling procedure

Since participants in this study were selected based on specific criteria (student in Groningen and daily traveling by bike), a non probability method was used. From this, a snowball sampling technique was placed in practice, where a survey was distributed via various social media platforms and asking participants to share the survey with people in their network who meet the criteria for the study. Additionally, data collection was also done by distributing flyers in a few specific locations where students stay the most frequently, such as study areas/libraries and student housing accommodations. As a result, these data gathering approaches would allow for the collection of diverse perspectives, which can lead to more comprehensive findings.

4.5. Data analysis

For the data analysis of this research, a statistical software called SPSS is used. First to organize the gathered data, descriptive statistics is created (see figure 3). Then, since this study is looking at the relationship between the 3 main concepts (PBE, PA, TS), to evaluate the data and to answer the research questions, spearman's rank correlation coefficient analysis is conducted. The spearman's rank correlation coefficient is suitable in this case since the research deals with ordinal data and it also indicates the strength and direction of the relationships between variables. Figure 3 illustrates the method and data analysis tools that were used to help explore each secondary question. The main question is then answered once each sub question is addressed.

In addition, as indicated in the theoretical framework, sociodemographic factors (age, gender, nationality, education) play a significant role in shaping PBE, PCA and TS. Hence, their relationship with the three main variables is examined and discussed. For data analysis of gender between the 3 main variables, and nationality with the 3 main variables, Mann Whitney tests were used. As for the rest of the factors (pursuing degrees and age) Kruskal wallis tests were performed.

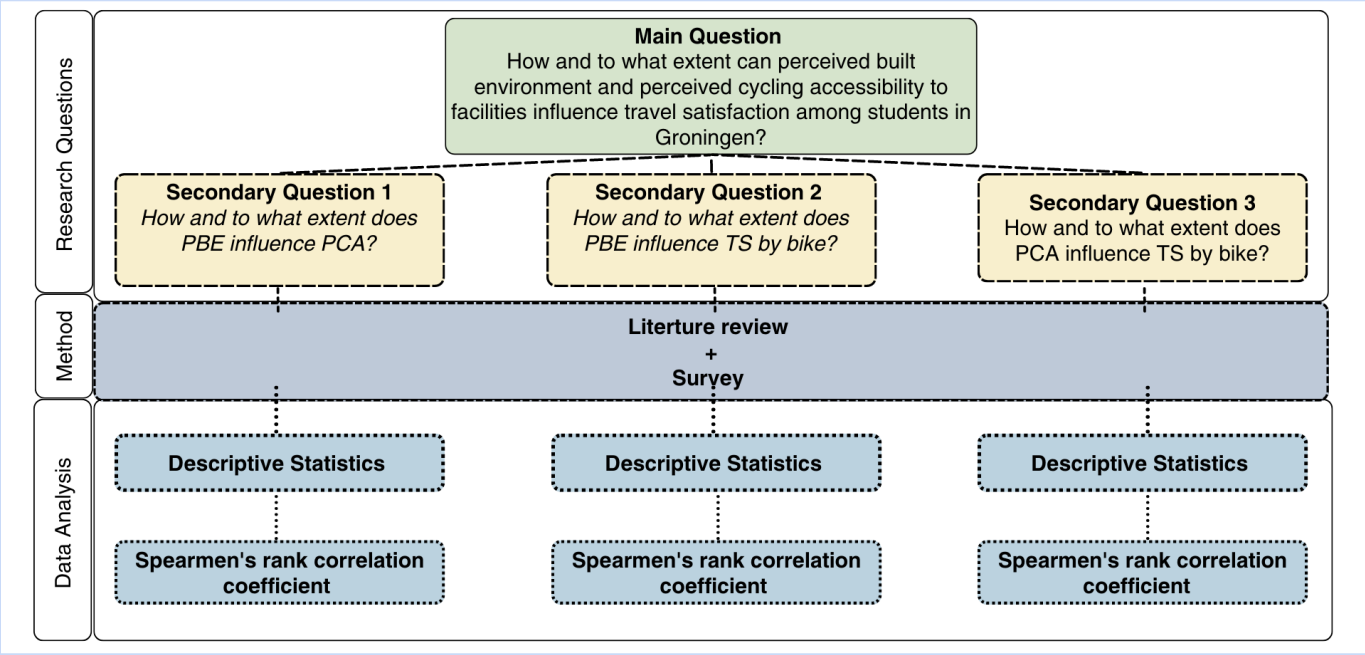

Figure 3: Data analysis scheme

4.6. Ethical considerations

To protect respondents' privacy, the survey was done anonymously, where no private information was collected. Moreover to ensure confidentiality, the survey was designed to be filled digitally. To guarantee

participants' privacy no personally identifiable questions were asked. By giving participants the option to skip any question that they did not feel comfortable answering, it ensured that throughout the entire process that their privacy was respected. When recruiting participants general information about the study was given to avoid any misconception and to make them fully aware of what the study entailed.

5. Results and Discussion

This section is divided into two parts. The descriptive results are first presented for each variable, and then, by referring to the sub-research questions, the relationship between them is analyzed and their associated sociodemographic factors are explored (inferential results).

5.1. Descriptive results

5.1.1. Socio-demographic data

A total of 73 responses were recorded through an online survey tool, Qualtrics. However, 24 were not filled out completely, therefore were removed, leaving the data set with only 49 valid cases. As also seen in figure 4, most of the respondents (65.3 %) were between the ages of 18 and 23. From the sample 75.5% of them were female, 59.2% were pursuing a bachelor's degree and 75.5% of the respondents were non dutch students.

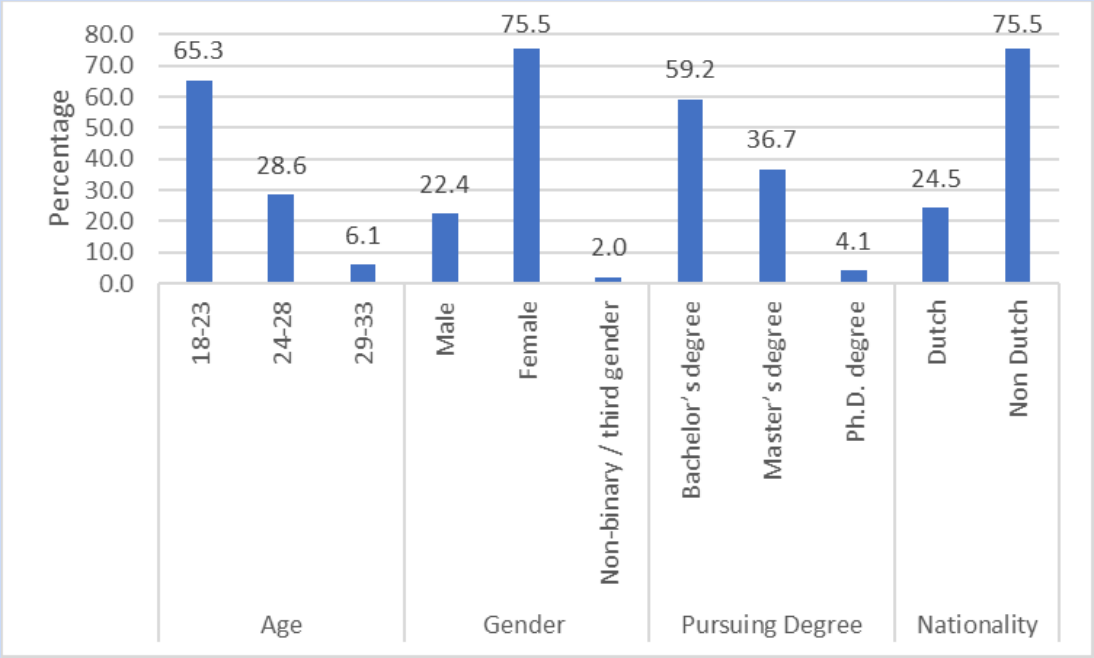

Figure 4: Socio-demographic variables of the sample

5.1.1. Perceived built environment, perceived cycling accessibility and travel satisfaction data

Table 1 gives a descriptive statistic of PBE and its associated indicators (PCI, PTV and PPSQ) with their statements. Each indicator's mean, mode and standard deviation were calculated by computing/grouping all their relevant statements. For the PCI indicator, both mode and median are 4, indicating a prevailing agreement of the grouped statements. This pattern is evident when examining each specific related statement that falls underneath the PCI, as the majority of respondents express agreement. It is noteworthy that, out of all PCI-related statements, the first one – "*In my living area, there are enough well-maintained bike paths that I can easily use when biking*"– received the highest and most frequent response, demonstrating strong agreement. This highlights a high level of consensus among students regarding their perceptions of the

availability and quality of bike paths in their living areas. Overall, the data suggest a high level of agreement among students towards the statements related to PCI.

Regarding the PTV, both the mode and median are 3, which denotes a state of neutrality. This suggests that the responses are evenly distributed across the levels of agreement. Therefore, this distribution shows that students hold diverse perspectives towards the overall PTV statements. Furthermore, this diversity becomes apparent when considering the standard deviation, which measures the dispersion of responses. It's interesting to note that the standard deviation (s.d=0.92168) of the PTV indicator is notably higher compared to the other indicators. This higher standard deviation implies a broader range of responses, reflecting a greater degree of variety in students' perspectives.

Considering the PPSQ indicator, it appears to have a mode of 4 which displays that the majority of respondents agree with the overall statements. This prevailing agreement is further supported by the median value of 4, suggesting a general tendency towards agreement. Moreover, this pattern of agreement is evident when examining each specific related statement that falls underneath the PPSQ indicator. Across all related statements of PPSQ, the majority of respondents express agreement as both the median and mode turn out to be 4.

To further comprehend the overall PBE, all statements from PCI, PTV and PPSQ were aggregated together and then the mode, median and standard deviation was calculated to provide a better understanding of the data. Given that each indicator had the majority of the responses fall towards the agreement level, the PBE mode and median are also 4, which suggest that the majority of respondents "agree" with the related statements of each indicator.

Table 1: Descriptive statistics of PBE and its statements

		Mode	Median	S.D
	Percived Built Environment	**4**	**4**	**0.56826**
	Percived Cycling Infrastructure	**4**	**4**	**0.66528**
Statements	In my living area there are sufficiently in good condition bike paths that I can easily use when biking	5	5	0.791
Statements	In my living area there are sufficient separated bicycle lanes that I can easily use when biking	4	4	1.017
Statements	In my living area there are convenient and safe biking racks for parking	4	4	1.243
Statements	The time spent waiting at traffic lights while cycling is too long	4	3	1.145
Statements	I feel safe when biking in my living area	4	4	0.727
Statements	I don't feel a lot of stress while biking in my living area	4	4	0.924
	Percived Traffic Volume	**3**	**3**	**0.92168**
Statements	I feel that there are many cyclists in the road	4	4	1.056
Statements	In my living area there are many cars that are parked on the road	4	3	1.071
Statements	In my living area there are too many cars on the road	3	3	0.984
	Percived Public Space Quality	**4**	**4**	**0.8753**
Statements	In my living area there is enough greenery and trees	4	4	0.997
Statements	In my living area, the public spaces have sufficient lighting	4	4	1.000
Statements	In my living area, the biking paths are aesthetically pleasant	4	4	1.023

Numbers ranging from strongly disagree (1) to strongly agree (5)

In Table 2, descriptive statistics for PCA variables are presented. For the overall PCA, given the mode and median being 5, it indicates that most of the respondents strongly agreed with the made statements. However, since the highest standard deviation in this table is 1.115, it is worth noting that the statement "It is easy to access Zernike campus by bike" received the most diverse responses compared to the other facilities. This

demonstrates a greater variation in perspectives regarding bike accessibility to the Zernike campus as compared to other facilities.

Table 2: Descriptive statistics of PCA and its statements

		Mode	Median	S.D
	Percived Cycling Accessibility	**5**	**5**	**0.84112**
Statements	It's easy to access supermarkets by bike	5	5	0.922
	It's easy to access the Zernike campus by bike	5	4	1.115
	It's easy to access public spaces and green areas by bike	5	5	0.930
	It easy to access my hobbies by bike	5	4	0.965

Numbers ranging from strongly disagree (1) to strongly agree (5)

Similarly to Table 1 and Table 2, Table 3 also provides descriptive statistics but for TS. In all of the statements the most frequent response was 6, which indicates that students are moderately satisfied when biking. In addition, compared with PBE and PCA, travel satisfaction statements have the most diverse responses. As shown in Table 3, the second statement elicited the most varied responses.

Table 3: Descriptive statistics of TS and its statements

		Mode	Median	S.D
	Travel Satisfaction	**6**	**5**	**1.33121**
Statements	I feel bored /tired/ fed up when I cycle; I feel enthusiastic/ alert/ engaged when I cycle	6	5	1.388
	I feel stressed/ worried/ hurried when I cycle; I feel relaxed/ calm/ confident when I cycle	6	5	1.542
	My cycling trips work poorly, are of a low standard, the worst imaginable; My cycling trips work well, are of a high standard, the best imaginable.	6	5	1.360

Numbers ranging from strongly dissatisfied (1) to strongly satisfied (7)

It is important to note that statements related to each main variable (PBE (PCI,PTV,PPSQ), PCA, TS) were computed using the median given that the median is the most effective indication of the data's central tendency for ordinal variables (Sullivan & Artino, 2013). Computing or grouping the variables is beneficial as it provides two purposes. Firstly it summarizes the collected data, allowing for a more in depth comprehension of the responses. Secondly, this grouping of related statements plays a crucial role in facilitating inferential statistics, as it allows for the investigation of relationships within the dataset. Therefore, the practice of computing the related statements together that help measure each main variable serves as a valuable step not only for descriptive analysis, but also for inferential statistics.

5.2 Inferential results

To make sense of the descriptive results displayed above, further tests were performed with SPSS. These tests aid in making inferences for the population parameters based on the sample statistics.

5.2.1. Relations with socio-demographic factors and PBE, PCA, TS variables

Figure 5 displays that most of the socio demographic variables do not show a significant relationship with PBE, PCA and TS. Mann Whitney test was used to investigate the difference for gender and nationality between the 3 main variables, however, the p-values (see figure 5) indicated a statistically insignificant difference between them. To explore the difference between pursuing degrees and PBE, PCA, TS, a Kruskal Wallis test was

performed, however, none of the variables showed a significant relationship. By using the Kruskal Wallis test, age revealed a significant difference (p-value=0.012) with PBE. This indicates that there is a low probability (less than 1.2%) that this difference occurred by chance.

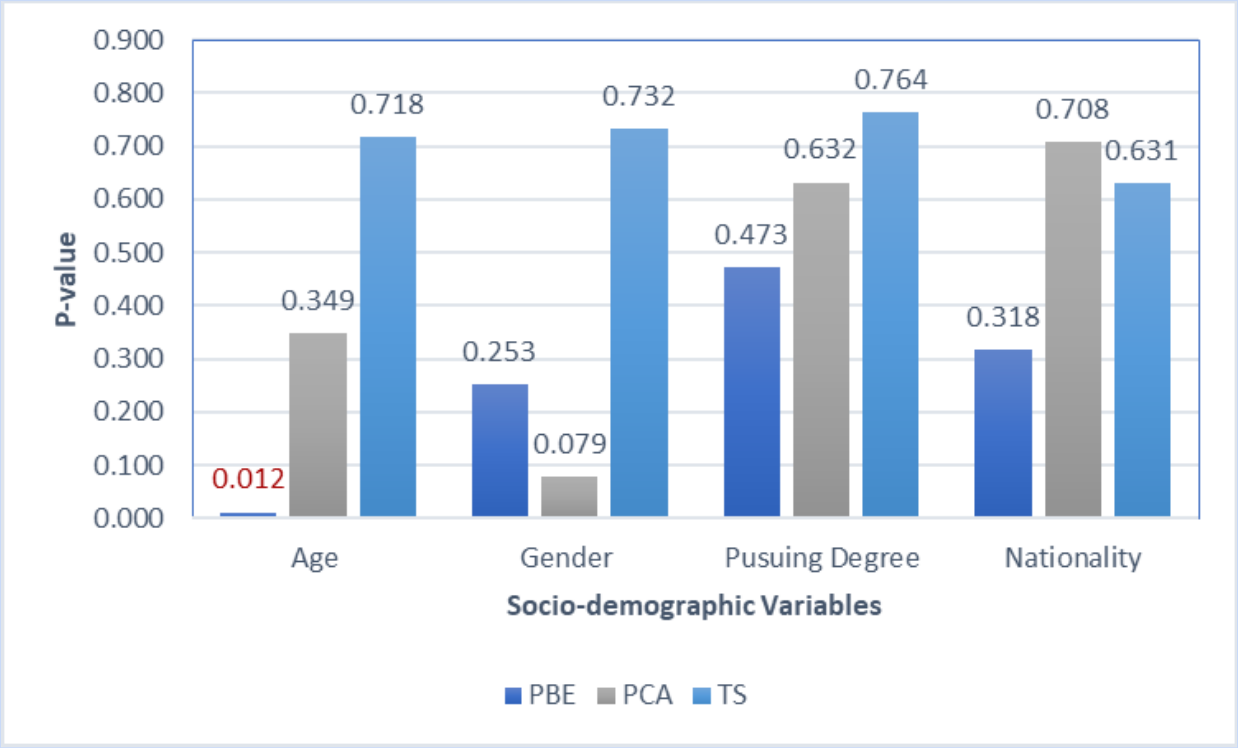

Figure 5: Outcomes of socio-demographic variables and PBE, PCA,TS

To further explore this difference, Table 4 demonstrates the distribution of PBE across various groups of age. Majority of students that were between the ages of 18 and 23 mostly agreed with the statements for PBE, which potentially indicates a high perception of the built environment. Majority of the students from 24 to 28, had a lower perception of the built environment, as the mode of PBE is 3. As for the students who were between the ages of 29 to 33, had higher perception of the build environment compared to those between the ages of 24 to 28. Nevertheless, by looking through Table 4 (total column), it can also be noticed that the distribution of age is also not even.

Table 4: Cross Tabulation outcomes of age and PBE

Age* PBE Crosstabulation

Count

		PBE			
		3.00	4.00	5.00	Total
Age	18-23	6	22	4	32
	24-28	9	4	1	14
	29-33	0	3	0	3
Total		15	29	5	49

5.2.2.Discussion of socio-demographic factors with perceived built environment, perceived accessibility and travel satisfaction

Based on the statistical results, we can only conclude that there is a potential difference between the age groups and perceived built environment. By referring to cross tabulation outcomes of age and PBE (see Table 4) and the mean rank (see appendix 2 - Table 1.4) it can be assumed that the highest perceived built environment is experienced by the age group of 29-33, followed by the age group of 18-23 and then the age group 24-28. However, it is important to note that the distribution of age groups is skewed which may impact the results. Given the age groups not being normally distributed (see appendix 2 - figure 1.1/figure 1.2) and the sample size not being that big, it increases the chance of a Type II error, which is failing to reject a false null hypothesis.

Moreover, most of these sociodemographic variables don't show a significant connection with perceived accessibility (similarly to the study by Vlugt et al. (2019), travel satisfaction and perceived built environment. Given that there is no significant difference between gender and both PBE and TS, it implies contradiction with the findings of Hu, Sobhani and Ettema (2023). Additionally, the findings depicted from figure 5, also contradict with the result of Lattman et al. (2019) where age and PCA was shown to have a significant relationship.

5.2.3.Relationship between perceived built environment and perceived cycling accessibility

Table 5: Outcomes of Spearman's rho for PBE and PCA

Correlations

			PBE	PCA
Spearman's rho	PBE	Correlation Coefficient	1.000	.479**
		Sig. (2-tailed)	.	<.001
		N	49	49
	PCA	Correlation Coefficient	.479**	1.000
		Sig. (2-tailed)	<.001	.
		N	49	49

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

To examine the connection between PBE and PCA a Spearman's rank correlation test is used. The null hypothesis for this test is as follows: *In the population there is no significant relationship between PBE and PCA*. As shown in Table 5, there is a significant correlation between PBE and PCA since the p- value is <0.001, which indicates that there is a meaningful relationship between the two variables. Due to the p value being significant, we can therefore reject the null hypothesis of this test. Besides the direction of the correlation, the test also provides the strength of this relationship which ranges from -1 to 1. As displayed in Table 5, the variables have a correlation coefficient of 0.479, which indicates a moderate positive correlation between PBA and PCA. As a result, this implies that higher levels of perceived built environment correspond to higher levels of perceived cycling accessibility.

Table 6: Outcomes of Spearman's rho for PCI, PTV, PPSQ and PCA

Correlations

			PCI	PTV	PPSQ	PCA
Spearman's rho	PCI	Correlation Coefficient	1.000	.187	.295*	.479**
		Sig. (2-tailed)	.	.198	.039	<.001
		N	49	49	49	49
	PTV	Correlation Coefficient	.187	1.000	-.098	.081
		Sig. (2-tailed)	.198	.	.503	.582
		N	49	49	49	49
	PPSQ	Correlation Coefficient	.295*	-.098	1.000	.423**
		Sig. (2-tailed)	.039	.503	.	.002
		N	49	49	49	49
	PCA	Correlation Coefficient	.479**	.081	.423**	1.000
		Sig. (2-tailed)	<.001	.582	.002	.
		N	49	49	49	49

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

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

However, when looking at the relationship between PA and each category of PBE more in depth, not all of them show a correlation with PCA (see Table 6). Particularly, PTV has a p-value (0.582) that is higher than 0.05 which indicates that there is no significant relationship between it and PCA. Besides being statistically insignificant, it also shows a weak positive correlation with PCA. On the other hand, as shown in Table 6, PPSQ and PCI are significantly correlated with PCA and that they both have a positive moderate relationship.

5.2.4. Discussion of perceived built environment and perceived cycling accessibility

Based on the test results, when looking at the PBE in general there is a significant positive relationship between it and PCA. Therefore this supports our preliminary first hypothesis that was based on the conceptual model. According to Table 1, the mode for PBE is 4, indicating that the participants fell in the mostly agreed category. When testing the correlation to investigate the relationship between PBE and PCA, a significant positive correlation was found, suggesting that in general participants who were more likely to agree with PBE statements were also more likely to have a positive perception of cycling accessibility. Nonetheless, not all PBE indicators (particularly PTV) ended up having a significant correlation with PCA. This suggests that indicators (PCI and PPSQ) within PBE who are statistically significant and have a higher correlation coefficient, may be more influential in driving the correlation with PCA.

5.2.5. Relationship between perceived built environment and travel satisfaction by bike

To examine the relationship between PBE and TS a Spearman's rho test was used again. The null hypothesis for this test and variables is as follows: *In the population there is no significant relationship between PBE and TS.* Based on Table 7, this relationship is statistically significant with a p-value of 0.030. A moderately positive correlation between the measured variables is shown by the correlation coefficient of 0.310. Thus, as there is a positive increase in the perception of the built environment, travel satisfaction by bike tends to increase as well.

Table 7: Outcomes of Spearman's rho for PBE and TS

Correlations

			PBE	TS
Spearman's rho	PBE	Correlation Coefficient	1.000	.310*
		Sig. (2-tailed)	.	.030
		N	49	49
	TS	Correlation Coefficient	.310*	1.000
		Sig. (2-tailed)	.030	.
		N	49	49

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

Nonetheless, when examining the connections between each PBE indicator and travel satisfaction, only PCI shows significant association with TS (see Table 8). PTV on the other hand has a very weak positive correlation (r=0.054) with TS, while PPSQ has a weak positive correlation (r=0.235) with TS, which is not significant because both have a p-value greater than 0.05.

Table 8: Outcomes of Spearman's rho for PCI, PTV, PPSQ and TS

Correlations

			PCI	PTV	PPSQ	TS
Spearman's rho	PCI	Correlation Coefficient	1.000	.187	.295*	.366**
		Sig. (2-tailed)	.	.198	.039	.010
		N	49	49	49	49
	PTV	Correlation Coefficient	.187	1.000	-.098	.054
		Sig. (2-tailed)	.198	.	.503	.714
		N	49	49	49	49
	PPSQ	Correlation Coefficient	.295*	-.098	1.000	.235
		Sig. (2-tailed)	.039	.503	.	.104
		N	49	49	49	49
	TS	Correlation Coefficient	.366**	.054	.235	1.000
		Sig. (2-tailed)	.010	.714	.104	.
		N	49	49	49	49

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

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

5.2.6. Discussion of perceived built environment and travel satisfaction by bike

According to the test findings, PBE and TS have a positive correlation overall, just like with PCA. Thus, this validates our initial second hypothesis which was based on the conceptual model. Similar to the results with PCA, not all PBE indicators show a significant correlation with TS; this may also suggest that some PBE indicators might have a stronger influence with TS. Based on Table 8, only PCI has a significant and a moderate positive correlation with TS. This suggests that PCI within PBE has the largest influence in driving the correlation with TS.

According to Table 1, the mode for PBE is 4, indicating that the participants fell in the mostly agreed category. When testing the correlation to investigate the relationship between PBE and TS, a significant positive correlation was found, suggesting that in general participants who were more likely to agree with PBE

statements were also more likely to have higher cycling satisfaction. Additionally this lines up with the findings of Hu, Sobhani and Ettema (2023), where PBE and TS were significantly associated with each other. Additionally the study also supports that there was a significant correlation between TS and traffic congestion, however, the results in Table 8 don't agree with this as the PTV is very weakly correlated and not statistically significant with TS.

5.2.7.Relationship between perceived cycling accessibility and travel satisfaction by bike

Table 9: Outcomes of Spearman's rho for PBA and TS

Correlations

			PCA	TS
Spearman's rho	PCA	Correlation Coefficient	1.000	.390**
		Sig. (2-tailed)	.	.006
		N	49	49
	TS	Correlation Coefficient	.390**	1.000
		Sig. (2-tailed)	.006	.
		N	49	49

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

For the relationship between PCA and TS, the following null hypothesis was tested: *In the population there is no significant relationship between PCA and TS.* Table 9 shows that the p-value is 0.006, which implies that the positive moderate correlation (0.390) between the variables is statistically significant. As a result, the null hypothesis of the test is rejected. When further exploring and seeing which specific activity correlates the most, it appears that access to supermarkets (r=0.352) and access to public space & green area (r= 0.297) correlates the most with overall travel satisfaction (see Table 10). This means that as the ease of access to supermarkets increases, travel satisfaction tends to increase as well, but the relationship is not very strong, the same applies for public/green spaces. However, access to Zernik campus and hobbies showed a weaker relationship with TS.

Table 10: Outcomes of Spearman's rho for PCA to Different Services and TS

Correlations

			It's easy to access supermarkets by bike	It's easy to access the Zernike campus by bike	It's easy to access public spaces and green areas by bike	It easy to access my hobbies by bike	TS
Spearman's rho	It's easy to access supermarkets by bike	Correlation Coefficient	1.000	.600**	.737**	.652**	.352*
		Sig. (2-tailed)	.	<.001	<.001	<.001	.013
		N	49	49	49	49	49
	It's easy to access the Zernike campus by bike	Correlation Coefficient	.600**	1.000	.601**	.654**	.258
		Sig. (2-tailed)	<.001	.	<.001	<.001	.073
		N	49	49	49	49	49
	It's easy to access public spaces and green areas by bike	Correlation Coefficient	.737**	.601**	1.000	.655**	.297*
		Sig. (2-tailed)	<.001	<.001	.	<.001	.039
		N	49	49	49	49	49
	It easy to access my hobbies by bike	Correlation Coefficient	.652**	.654**	.655**	1.000	.249
		Sig. (2-tailed)	<.001	<.001	<.001	.	.085
		N	49	49	49	49	49
	TS	Correlation Coefficient	.352*	.258	.297*	.249	1.000
		Sig. (2-tailed)	.013	.073	.039	.085	.
		N	49	49	49	49	49

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

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

5.2.8. Discussion of perceived cycling accessibility and travel satisfaction by bike

The results of the test indicate that PCA and TS overall have a positive direct relationship. This therefore supports the conceptual model-based third hypothesis made in *Section 3*. Referring to Table 2, the mode for PCA is 5, indicating that the participants fell in the strongly agreed category. When the correlation between PCA and TS was assessed, there was a significant positive association between them, implying generally that those who strongly agreed with services being easily accessible by bike were also more likely to report higher satisfaction with cycling. Additionally, these findings also line up with the research of Lättman et al. (2019), which found that a positive perception of accessibility had a beneficial impact on travel satisfaction.

6. Conclusion

This study's objective was to identify the relationship between perceived built environment, perceived cycling accessibility and travel satisfaction. Its main aim was also to explore the degree of influence that perceived build environment and cycling accessibility had on travel satisfaction by bike among students in Groningen.

To answer the first part of the main question of this study, " *How can perceived built environment and perceived cycling accessibility to facilities influence travel satisfaction by bike among students in Groningen?",* the relationship between each main variable was investigated with the support of literature review. These results showed that PA influences travel satisfaction directly. On the other hand, PBE influences travel satisfaction directly and indirectly through PA.

To answer the second part of the main question, "*To what extent can perceived built environment and perceived cycling accessibility to facilities influence travel satisfaction by bike among students in Groningen?" quantitative* research was carried out in the area and analyzed through statistical tests. The results demonstrate a moderate positive relationship between PBE and TS. However, PCI within PBE was the most influential on TS. Similarly, the results of the analysis for PBE and PCA to different facilities illustrate that there is a moderate positive relationship between them. However only PCI and PPSQ were more influential on PCA.

Additionally, the results for PCA in general displayed a significant moderate correlation with travel satisfaction. However, ease of access by bike to supermarkets and public space/green areas had the highest influence on TS.

6.1. Recommendations for planning practice

This research has shown that by enhancing perceived built environment can improve travel satisfaction by bike. Since PCI was more influential on both TS and PCA, it is crucial to design a bike infrastructure that is both functional and safe. Planners can achieve this through various measures such as creating good conditioned bike paths, adding biking racks for parking and improving street lighting. Additionally the research also showed that by enhancing the perceived cycling accessibility can improve travel satisfaction by bike. This may be done by establishing practical bike paths that connect residential areas with frequently visited facilities especially with supermarkets and public green areas. Ultimately, these spatial improvements will assist in creating a more livable environment.

6.2. Limitations and future research

6.2.1. Data collection

Although multiple approaches were used to gather data, not a lot of responses were collected; out of 73 responses, 24 were not fully completed. Since the survey was only available in the English language, it is possible that a language barrier existed because the majority of participants were non Dutch students, according to sociodemographic factors (see figure 4). Considering that data were collected during the exam academic period, it is also possible that the time was not ideal. Moreover, the chances that participants provided biased responses due to social desirability bias may also exist especially when collecting data when using snowball sampling through social media platforms. Future studies can overcome these limitations by conducting research at various times of the year and applying multiple methods of data collection. The research only explores the student population in Groningen, hence may not be applicable to generalize its results to other groups of population. This, however, could be addressed in future studies by using a more diverse sample.

6.2.2. Data analysis

Due to a scarcity exploration of PBE, PCA and TS relationship, the literature available on this specific topic is limited. This consequently also limits the data analysis where not a lot of connection can be made with previous studies. Hence, future research is necessary to further explore this relationship and deepen understanding. Additionally, to increase reliability and validity of results, it's important for future studies to incorporate a larger sample size.

For data analysis, given the small sample of 49 respondents, the majority of the tests used are of non parametric tests. Using non parametric tests are beneficial particularly in small sample sizes to provide reliable results. However, these tests tend to have its limitations by having less statistical power than the parametric counterpart. Hence, for future studies it is advantageous to consider using parametric tests such as t-test, ANOVA and regression analysis for larger sample sizes. Moreover, considering using structural equation modeling in future studies could better investigate the complex link between multiple variables. These statistical methods could lead to deeper understanding as it can test correlations that are both direct and indirect between various variables.

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8. Appendices

Appendix 1

Table 1a.: Overview of survey

Questions/Statements	Answer choices	Type of data	Objective
Sociodempgraphic • What is your age? _____ • What is your gender? _____ • What degree are you currently doing? _____ • What is your nationality?	☐ 18- 23 ☐ 24-28 ☐ 29-33 ☐ 34-38 _____ ☐ Male ☐ Female ☐ Other _____ ☐ Bachelor's degree ☐ Master's degree _____ ☐ Dutch ☐ Non Dutch	Nominal	Sociodemographic factors such as age, gender, education, and nationality of the participants are collected to explore if there is any link between them and PBE, PCA, TS.
PBE *PCI* • In my living area there are sufficiently in good condition bike paths that I can easily use when biking • In my living area there are sufficient separated bicycle lanes that I can easily use when biking • In my living area there are convenient and safe biking racks for parking • The time spent waiting at traffic lights while cycling is too long. • I feel safe when biking in my living area • I don't feel a lot of stress while biking in my living	1= strongly disagree 2= disagree 3= neutral 4= agree 5= strongly agree	Ordinal	To measure PBE, statements for each of its indicators (PCI, PTV, PPSQ) are made. Each statement is derived by the theoretical framework section (see chapter 2). However these statements to measure PCI, PTV and PPSQ are mainly inspired by the study of Blitz (2021).

area _____ *PTV* • I feel that there are many cyclists in the road • In my living area there are many cars that are parked on the road • In my living area there are too many cars on the road _____ *PPSQ* • In my living area there is enough greenery and trees • In my living area, the public spaces have sufficient lighting • In my living area, the biking paths are aesthetically pleasant			
PCA • It's easy to access supermarkets by bike • It's easy to access the Zernike campus by bike • It's easy to access public spaces and green areas by bike • It easy to access my hobbies by bike	1= strongly disagree 2= disagree 3= neutral 4= agree 5= strongly agree	Ordinal	To measure PCA a destination/activity specific approach is used. For this part, general daily facilities (supermarkets, university campus, public/green areas and hobbies) visited by students in the city are picked.
TS • I feel bored /tired/ fed up when I cycle; I feel enthusiastic/ alert/ engaged when I cycle • I feel stressed/ worried/ hurried when I cycle; I feel relaxed/ calm/ confident when I cycle • My cycling trips work poorly, are of a low standard, the worst imaginable; My cycling trips work well, are of a high standard, the best imaginable	1=Extremely dissatisfied 2=Moderately dissatisfied 3=Slightly dissatisfied 4=Neutral 5=Slightly satisfied 6=Moderately satisfied 7=Extremely satisfied	Ordinal	TS is measured by a cognitive evaluation and two affective evaluations (positive deactivation and positive activation). These statements are inspired by Lättman et al., (2019) and Friman et al., (2013).

Table 2a: Number of respondents received in specific days (*table extracted from Qualtrics*)

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Monday, April 17th 2023	0.50	1.00	0.81	0.17	0.03	17
2	Tuesday, April 18th 2023	0.80	1.00	0.90	0.09	0.01	5
3	Wednesday, April 19th 2023	0.60	1.00	0.86	0.11	0.01	19
4	Thursday, April 20th 2023	0.70	1.00	0.87	0.12	0.02	3
5	Friday, April 21st 2023	0.80	0.80	0.80	0.00	0.00	1
6	Monday, April 24th 2023	0.90	0.90	0.90	0.00	0.00	2
7	Tuesday, April 25th 2023	0.90	0.90	0.90	0.00	0.00	2
8	Wednesday, April 26th 2023	0.90	0.90	0.90	0.00	0.00	1
9	Friday, April 28th 2023	1.00	1.00	1.00	0.00	0.00	3
10	Monday, May 1st 2023	0.90	0.90	0.90	0.00	0.00	2
11	Tuesday, May 2nd 2023	0.80	1.00	0.93	0.09	0.01	3
12	Tuesday, May 9th 2023	0.90	0.90	0.90	0.00	0.00	1
13	Wednesday, May 10th 2023	0.70	0.70	0.70	0.00	0.00	1
14	Thursday, May 11th 2023	0.80	0.80	0.80	0.00	0.00	1
15	Friday, May 12th 2023	0.90	1.00	0.94	0.05	0.00	7
16	Saturday, May 13th 2023	0.90	1.00	0.97	0.05	0.00	3

Figure 1a: Survey flyer

Appendix 2

Nationality

Ranks

	What is your nationality?	N	Mean Rank	Sum of Ranks
PBE	Dutch	12	28.21	338.50
	Non Dutch	37	23.96	886.50
	Total	49		
PCA	Dutch	12	26.25	315.00
	Non Dutch	37	24.59	910.00
	Total	49		
TS	Dutch	12	26.67	320.00
	Non Dutch	37	24.46	905.00
	Total	49		

Test Statistics[a]

	PBE	PCA	TS
Mann-Whitney U	183.500	207.000	202.000
Wilcoxon W	886.500	910.000	905.000
Z	-.999	-.374	-.480
Asymp. Sig. (2-tailed)	.318	.708	.631

a. Grouping Variable: What is your nationality?

Gender

Ranks

	What is your gender?	N	Mean Rank	Sum of Ranks
PBE	Male	11	28.32	311.50
	Female	37	23.36	864.50
	Total	48		
PCA	Male	11	30.59	336.50
	Female	37	22.69	839.50
	Total	48		
TS	Male	11	23.27	256.00
	Female	37	24.86	920.00
	Total	48		

Test Statistics[a]

	PBE	PCA	TS
Mann-Whitney U	161.500	136.500	190.000
Wilcoxon W	864.500	839.500	256.000
Z	-1.144	-1.758	-.343
Asymp. Sig. (2-tailed)	.253	.079	.732

a. Grouping Variable: What is your gender?

Age

Ranks

	What is your age?	N	Mean Rank
PBE	18-23	32	28.34
	24-28	14	16.39
	29-33	3	29.50
	Total	49	
PCA	18-23	32	27.00
	24-28	14	21.00
	29-33	3	22.33
	Total	49	
TS	18-23	32	25.52
	24-28	14	22.89
	29-33	3	29.33
	Total	49	

Test Statistics[a,b]

	PBE	PCA	TS
Kruskal-Wallis H	8.878	2.108	.664
df	2	2	2
Asymp. Sig.	.012	.349	.718

a. Kruskal Wallis Test

b. Grouping Variable: What is your age?

Table 1.4: *Outcomes of age groups and PBE,PCA,TS*

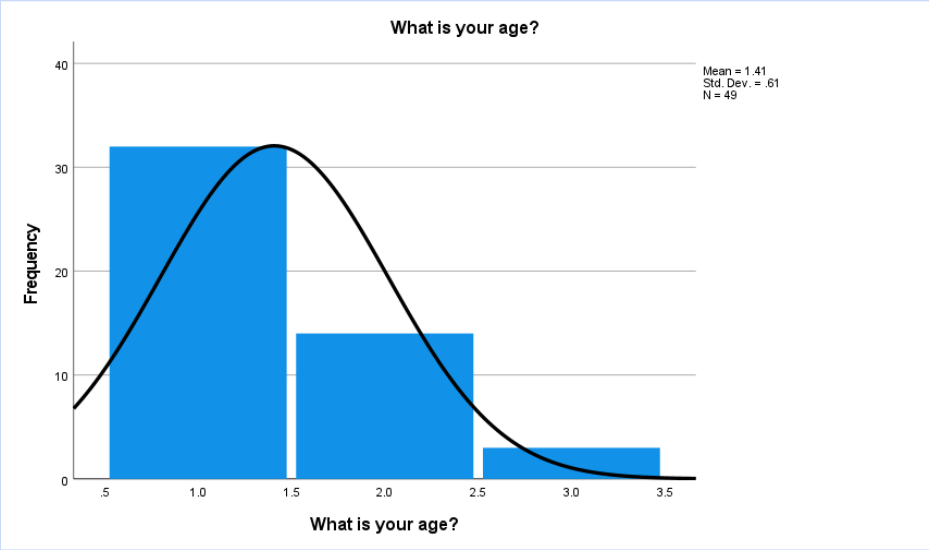

Figure 1.1 : Age distribution of sample

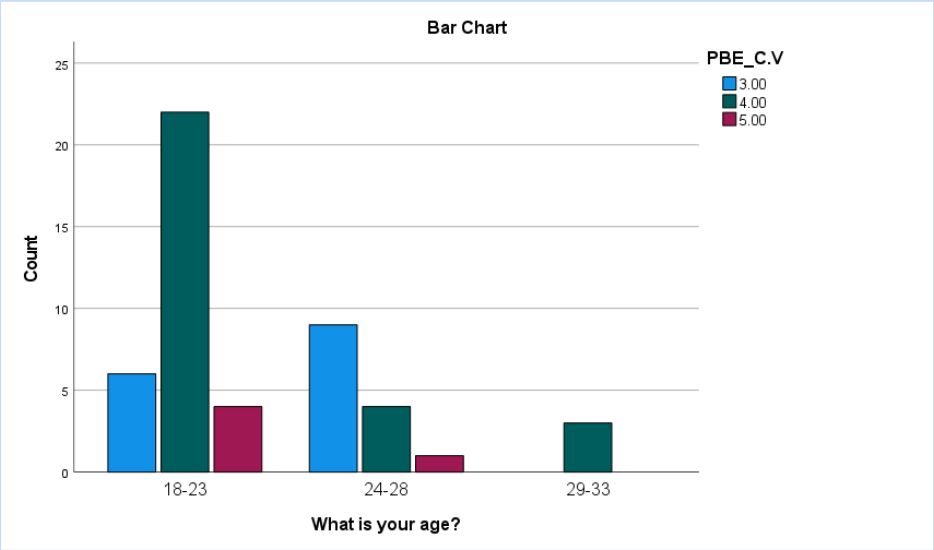

Figure 1.2: Sample's age distribution across PBE range

Education

Ranks

	What degree are you currently pursuing?	N	Mean Rank
PBE	Bachelor's degree	29	26.45
	Master's degree	18	22.17
	Ph.D. degree	2	29.50
	Total	49	
PCA	Bachelor's degree	29	25.91
	Master's degree	18	22.92
	Ph.D. degree	2	30.50
	Total	49	
TS	Bachelor's degree	29	24.14
	Master's degree	18	25.72
	Ph.D. degree	2	31.00
	Total	49	

Test Statistics[a,b]

	PBE	PCA	TS
Kruskal-Wallis H	1.499	.919	.538
df	2	2	2
Asymp. Sig.	.473	.632	.764

a. Kruskal Wallis Test

b. Grouping Variable: What degree are you currently pursuing?