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# BICYCLE INFRASTRUCTURE AND TRANSPORTATION POVERTY: A SUSTAINABLE PERSPECTIVE AND CASE STUDY OF UT AUSTN

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*Abstract*

***Bicycle infrastructure and transportation poverty are critical issues demanding accessible, sustainable, and economical solutions for the diverse population of the United States. While extensive research has been conducted to improve public transportation facilities, ongoing development of infrastructure is essential to address daily commuting challenges and ensure affordability across all socio-economic classes.***
***This study focuses on evaluating public transportation systems surrounding the University of Texas at Austin, emphasizing bicycle infrastructure. It explores strategies to enhance existing conditions, promote bicycle usage, and achieve healthier, sustainable solutions. A thorough literature review compares Austin's bicycle infrastructure to exemplary systems in the Netherlands and England, offering insights into globally recognized practices.***
***To provide a robust analysis, a targeted survey was conducted, yielding data on current infrastructure issues. Furthermore, the Analytic Hierarchy Process (AHP) was employed to evaluate potential solutions and establish recommendations for implementation. This report prioritizes the analysis of current conditions, integration of global best practices, and actionable suggestions to increase bicycle usage within and around the UT-Austin campus.***

***Keywords: Bicycle Infrastructure, Public Transport Systems, Sustainable Urban Mobility, Analytic Hierarchy Process (AHP), Bicycle Usage Optimization, Infrastructure Development, Socio-Economic Approach.***

## I. INTRODUCTION

Rising parking rates and expensive gas prices have led to extensive growth in walking, biking, and physical activities across the United States (Sener et al., 2021). Between 2009 and 2016, Austin, Texas, witnessed a nearly 30% increase in the number of individuals walking or biking to school or work (U.S. Census Bureau, 2017). However, 70% of the population still relies on personal vehicles for daily errands, citing reasons such as inadequate biking lanes, a lack of secure parking spaces, and unsafe road conditions. This study addresses the underutilization and marginalization of bicycling as a mode of transportation, highlighting the neglect of bicycle infrastructure and funding that has resulted in unsafe environments for cyclists (Marlin, 2008).
A comparative analysis of global best practices—such as those employed in the Netherlands and England—demonstrates the advantages of bicycling for college students, including low operational costs, adequate travel speeds, and the flexibility of departure times relative to other modes of transit like buses or trains (Akar & Clifton, 2009). Bicycling also offers substantial health benefits and environmental advantages, such as zero emissions and accessibility for cost-conscious

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students living near campuses (Akar & Clifton, 2009).
Despite these benefits, bicycles remain underutilized on university campuses across the U.S. (Akar & Clifton, 2009). Public transport infrastructure, particularly biking facilities, requires remodelling to address transportation poverty and encourage the use of non-motorized modes of transportation. Promoting active transportation aligns with public health, environmental conservation, and urban planning goals, yielding benefits like improved air quality, reduced traffic congestion, and enhanced physical activity levels (Grabow et al., 2012; Rissel, 2009; Sener, Lee, & Elgart, 2016).
This study analyses the current bike and bus infrastructure within a 5–6-mile radius of the University of Texas at Austin campus. Using data from a brief survey, key issues with biking facilities are identified, and economic remedies are proposed to mitigate these problems through sustainable methods. The research incorporates the Analytic Hierarchy Process (AHP) to prioritize recommendations for infrastructure improvements.

### 1.1. Key Objectives:

1. Assessing existing infrastructure and transportation poverty.
2. Highlighting best practices from leading international models.
3. Conducting a survey for practical insights into local challenges.
4. Utilizing AHP to propose informed recommendations for improvement.

### 1.2. Organization of Report

1. Theoretical Background: An overview of biking infrastructure challenges and opportunities.
2. Literature Review: Comparative analysis of best practices from leading countries.
3. Case Study and Methodology: Development of a research framework to analyse local infrastructure and propose modifications.
4. Findings and Recommendations: Evaluation of survey results and AHP outcomes to identify solutions.
5. Conclusion: Summary of key findings and actionable insights.

## II. BACKGROUND

The lack of adequate cycling and public transport facilities poses a significant challenge to cities across the United States. While many urban areas are proactively addressing cycling issues to benefit both individuals and society as a whole (Marlin, 2008), there is still considerable progress to be made. Austin, Texas, for instance, has earned a silver-level designation as a bicycle-friendly community. Despite this recognition, many residents, particularly students, remain hesitant to commute by bike due to safety concerns and limited reliance on public transport.
From 2007 to 2020, the Texas Department of Transportation (TxDOT) Austin District recorded over 8,000 pedestrian-vehicle and bicycle-vehicle crashes resulting in fatalities or serious injuries, underscoring the urgent need for remedial action (Sener et al., 2021). This alarming statistic highlights the pressing need for city transport planners to evaluate the current infrastructure and implement strategies to enhance safety and accessibility for cyclists.

Extensive research indicates that safety is a primary concern for cyclists, and the most critical improvements involve expanding biking facilities and providing secure parking options (Marlin, 2008). Various factors influence individuals' decisions to adopt bicycles as a mode of commuting, including the availability of safe biking lanes, secure parking spaces, road gradient, accessibility, directness of routes, and overall convenience. Addressing these factors not only ensures cyclists' safety but also encourages broader adoption of bicycles, contributing to a reduction in pollution and fostering a healthier and more sustainable future.

Planning and developing bicycle infrastructure, however, is a highly intricate process, especially in busy urban environments or around bustling university campuses. Several key considerations must be addressed to ensure effective infrastructure design, which can broadly be categorized into the following perspectives:

1. User-Cantered Perspective: This includes factors such as travel demand, traffic volume, truck percentages, urban traffic conditions, road network density, mode share statistics, population density, cyclist experience levels, and bike density.
2. Design Perspective: Factors include bicycle route planning, dedicated bike lanes and paths, intersection design, parking facilities, bike-ability indices, connectivity, transit coverage, and predictive modelling for future usage.
3. Government and Policy Framework: Federal and municipal contributions include funding allocations, maintenance strategies, conflict mapping, city-wide planning, regulation enforcement, public education initiatives, and sustainable travel incentives.

Recognizing the multifaceted nature of bicycle infrastructure planning, this report narrows its focus to the bicycle infrastructure within and around the University of Texas at Austin campus. Drawing on a comprehensive literature review, survey findings, and an application of the Analytic Hierarchy Process (AHP), this study identifies significant gaps in the current infrastructure and proposes targeted action plans to address these issues.

## III. LITERATURE REVIEW

The rapid growth and diversification of the U.S. automotive industry have significantly influenced the development of urban infrastructure, prioritizing automobiles for public usage. This over-reliance on automobiles has led to a reduction in transportation diversity and has contributed to widespread issues, including environmental degradation, public health challenges, and inefficient land use (Gardner, 1998). Contemporary land-use practices have increasingly favoured urban sprawl, exacerbated traffic congestion and air pollution while compromising the safety and comfort of pedestrians and bicyclists, who remain the most vulnerable users of urban areas (Balsas, 2002). Furthermore, the United States faces alarming health risks, including rising rates of physical inactivity, obesity, and cardio diseases (Killingsworth et al., 2003; Moudon & Lee, 2003).

Bicycling remains an underutilized and marginalized mode of transportation, with the overdependence on automobiles directly contributing to its limited adoption. The lack of sufficient funding and infrastructure for bicycling has further created unsafe environments for cyclists (P5). In 2021 alone, the Texas Department of Transportation (TxDOT) Austin District reported 7,631 injuries and crashes involving pedestrians or bicyclists, highlighting the pressing need to address safety concerns for active travellers (Sener et al., 2021). Research indicates that crash occurrences are influenced by environmental factors, which can be broadly categorized into travel demand, road network design, land use practices, and sociodemographic characteristics. These factors vary based on the context of the study area and are essential to understand for establishing safety goals with limited resources.

European countries such as the Netherlands, Denmark, and Germany exemplify successful models for bicycle infrastructure development. These nations boast extensive, well-integrated networks of bike lanes and bicycle-oriented intersection designs, supported by strong government policies. For instance, the Dutch government actively promotes cycling through tax benefits for bicycle purchases, investment in bicycle parking facilities near public transport hubs, and measures to prevent theft and enhance security (Heinen et al., 2013). Additionally, the Dutch "feeder model" connects bicycle infrastructure with railway stations, providing a seamless and economical travel option. This approach not only reduces reliance on motorized transport but also enhances the accessibility and efficiency of high-speed rail systems (Rietveld, n.d.).

Austin, Texas, exhibits immense potential for developing its bicycle infrastructure, contingent upon prioritization as a policy and academic agenda. The League of American Bicyclists classifies U.S. cities into four categories of bicycle friendliness—Bronze, Silver, Gold, and Platinum. While Austin is designated as a silver-level bicycle-friendly city, there remains significant room for improvement. Cyclists have identified the following key areas for enhancement in Austin:

1. Expansion and connectivity of bicycle lanes and paths.
2. Integration of bicycles with public transportation systems.
3. Improved traffic enforcement and cyclist education.
4. Large-scale land-use planning to support utilitarian cycling (Marlin, 2008).

The University of Texas at Austin campus has the opportunity to transform its bicycle infrastructure into a viable and preferred mode of transportation for its students. The primary objective should be the creation of a cohesive network of bicycle paths that integrates seamlessly with other transit options. Adopting the Netherlands' feeder model, for example, could provide students with efficient last-mile connectivity. Factors influencing individuals' decisions to choose bicycles, such as weather conditions, travel distance, socioeconomic characteristics, and attitudes toward cycling, must be carefully considered.

The survey conducted in the subsequent section explores these factors in greater detail, shedding light on the determinants of cycling usage within and around the UT Austin campus. Encouraging non-motorized modes of transportation aligns with critical goals at the intersection of student health, environmental sustainability, and transportation.

## IV. CASE STUDY

University campuses present unique challenges and opportunities in infrastructure planning due to their high population density, stringent safety requirements, homogeneity in age groups, and shared educational purpose. These complexities demand careful consideration of multiple perspectives, including campus functionality, safety, accessibility, and sustainability. This case study focuses on the biking and public transport infrastructure within and around the University of Texas (UT) at Austin campus, analysing existing conditions and proposing potential modifications to promote sustainability.

The UT Austin campus is a city campus situated a few streets from downtown Austin. It hosts a diverse population, predominantly students aged 18 to 25, all pursuing academic excellence. As noted by Burns (2001), "the physical design of the campus makes a fundamental contribution to the pursuit of academic excellence." Consequently, infrastructure planning must prioritize both functionality and sustainability to support the campus environment effectively. Thousands of faculty members, students, and staff depend on campus access daily, making sustainable transportation solutions vital for promoting environmental stewardship and a greener future. There is growing interest among universities in addressing local congestion, reducing greenhouse gas emissions, and championing sustainable development (Akar & Clifton, 2009).

### 4.1. Bicycling as a Sustainable Solution

Bicycling offers significant benefits as a mode of sustainable transportation, including health advantages and cost-effectiveness, particularly for students. Several official City of Austin Bike Routes connect to or near the UT campus, marked with signs designating them as part of the city's bicycle route network. These streets were selected based on characteristics conducive to cyclist safety, such as lower travel speeds, reduced traffic volumes, or their connectivity to other key routes (Rosenbarger & Elizabeth M, n.d.).

Frequently travelled streets around the campus include Speedway, Dean Keeton, Congress Avenue, MLK Jr. Blvd, San Jacinto, Guadalupe, Red River, Duval Street, and West Campus. Among these, some have designated biking lanes, while others lack such facilities. Guadalupe, Dean Keeton, Red River, and MLK Jr. Blvd form the perimeter of the campus and share certain commonalities: two-way traffic flow, sidewalks on both sides, varying centre turn lanes, and a minimum of four lanes with high auto traffic volumes. Despite these provisions, students often feel more comfortable commuting by car or bus than by bike. Factors such as a lack of secure parking spots, high traffic volume, variable road gradients, and inadequate biking facilities contribute to this hesitation.

### 4.2. Research Methodology

To comprehensively understand the reasons behind limited bicycling usage around the UT campus, this study is conducted in three parts:

1. Literature Review: Analysing global best practices in bicycle infrastructure, focusing on approaches adopted by leading countries like the Netherlands and Denmark.
2. Participatory Survey: Collecting qualitative and quantitative data from UT Austin students to evaluate current conditions, challenges, and their perspectives on bicycling infrastructure.
3. Analytic Hierarchy Process (AHP): Developing a correlation matrix to assess and prioritize potential solutions based on factors such as safety, accessibility, and economic feasibility.

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## V. RESULTS AND DISCUSSION

As part of the case study, a survey was conducted to evaluate the bicycle infrastructure in and around the University of Texas at Austin campus. The survey, distributed among students during the research period, garnered a total of 51 responses. While the sample size is relatively small due to the limited time available, the findings provide valuable insights into current trends and challenges. Below are the key findings-

### 5.1. Bicycle Usage:

1. Only 11.8% of respondents reported using bicycles for daily travel to the university.
2. Another 23.5% use bicycles occasionally.
3. A significant 45.1% of respondents indicated that they never use bicycles for commuting to campus, highlighting a substantial gap in bicycle adoption.

### 5.2. Reasons for Limited Usage:

The low usage of bicycles can be attributed to several key issues, including:

1. Safety Concerns: A lack of safe road conditions, exacerbated by high motor traffic volumes, is one of the primary deterrents. The absence of clear policies to create a safe environment for cyclists further compounds this issue.
2. Insufficient Infrastructure: Respondents pointed out the lack of secured parking spaces and inadequate cycling lanes as major hurdles.
3. Theft Risk: Increased incidents of bicycle theft at parking stations discourage students from using bicycles as their primary mode of transportation.

### 5.3. Distance to Campus:

According to the survey (referencing Figure 3), 66.7% of respondents, or 34 students, reside within a radius of 1–3 miles from the campus. This distance is considered ideal for bicycle commuting. However, the barriers highlighted above play a critical role in students' decision-making, ultimately reducing the likelihood of choosing bicycles as a commuting option.

These findings underscore the pressing need to address safety, infrastructure, and security concerns to promote bicycle usage among students. The issues revealed by this survey serve as a foundation for the subsequent analysis, where potential solutions will be explored and prioritized.

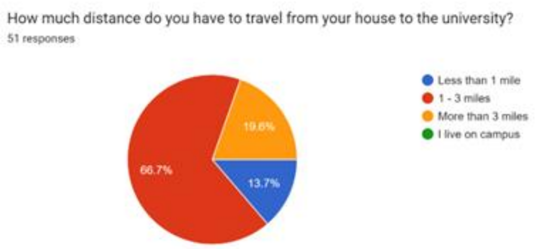


Fig. 1. Distance Survey

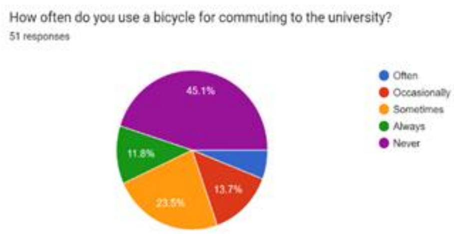


Fig. 2. Bicycle Commute Survey

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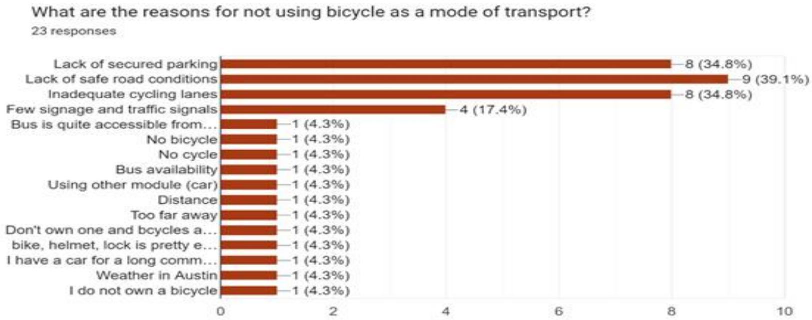


Fig. 3. Survey for not using Bicycle

The survey results presented in Figure 4 reveal the key factors that respondents consider when selecting a bicycle route. The findings emphasize several critical aspects that shape bicycling decisions among students commuting to and within the University of Texas at Austin campus.

### 5.4. Key Factors

1. Gradient of the Road: The road gradient emerges as one of the most significant factors in deciding a bicycle route. Steeper gradients hinder early morning commutes, especially when students require convenient and effortless travel to campus. Easier, flatter routes encourage bicycle usage by reducing physical exertion and enhancing accessibility.
2. Shortest Accessible Path: Time constraints often play a major role in route selection. Students prioritize the shortest accessible path to minimize travel time and effort, making it a favoured option over longer, physically demanding routes.
3. Safe Road Conditions: Safety remains paramount for Austin bicyclists, with traffic volume being a key consideration. High volumes of motorized traffic deter cyclists, necessitating safer roads and dedicated bicycle lanes to promote cycling as a viable mode of transportation.
4. Availability of Cap Metro Bus Service: The presence of hybrid travel options contributes significantly to route preferences. Students often combine bicycle travel with public transportation, using bicycles to reach nearby bus stops and leveraging the Cap Metro bus service for the remainder of their commute. Once on campus, bicycles are then used to navigate different destinations throughout the day.

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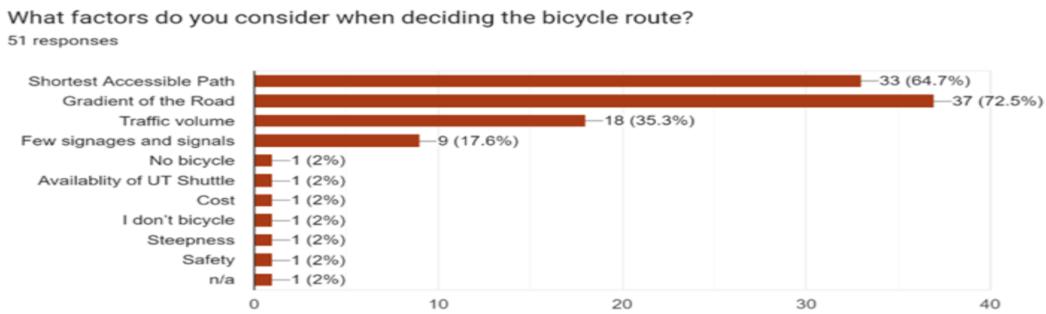


Fig. 4. Survey for Bicycle Route

The survey data highlights that buses and private vehicles are the most preferred modes of transportation among students, with bicycles being less commonly used. The popularity of the Cap Metro bus service can be attributed to its cost-effectiveness, as it is free of charge for UT students. Additionally, the well-structured bus routes make it convenient for students to travel to and around the campus, providing accessibility to numerous locations with ease.

However, one limitation of the bus service is the significantly longer travel time compared to private vehicles. This factor contributes to the car being the second most preferred option for commuting. Despite the convenience of reduced travel time, the high cost of purchasing and maintaining a car limits its usage, with only 13 students selecting it as their preferred mode of transportation.

These preferences underline the importance of offering a diverse range of transportation options while addressing existing gaps in infrastructure. For instance, improving bicycle infrastructure and integrating hybrid transportation methods—such as combining bicycles with public transit—could alleviate the overreliance on motorized vehicles and encourage more sustainable commuting practices.

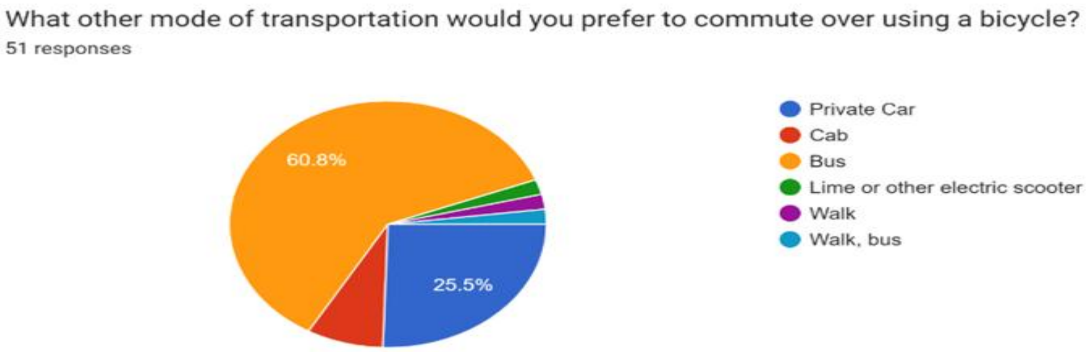


Fig. 5. Survey for Mode of Transportation

Following the compilation and analysis of survey results, the Analytic Hierarchy Process (AHP) was applied to perform pair-wise comparisons of physical infrastructure attributes and the factors influencing bicyclists' choices when using bicycles as a mode of transportation.

### 5.5. Physical Infrastructure Attributes

The study considered the following four attributes:

1. Consistency: Refers to the uniformity and reliability of bicycle infrastructure, ensuring seamless connectivity across routes.
2. Directness: Emphasizes the importance of providing the shortest and most accessible paths to minimize travel time.
3. Comfort: Takes into account features that enhance the ease of bicycling, such as smooth terrain and ergonomic routes.
4. Attractiveness: Covers aesthetic elements that encourage bicycling, such as scenic paths and overall infrastructure appeal.

### 5.6. Factors Influencing Decisions

Based on survey data and analysis, the following factors were prioritized:

1. Secured Parking Spaces: Availability of safe and theft-proof parking facilities, which was a primary concern highlighted by respondents.
2. Number of Biking Lanes: Accessibility and connectivity through dedicated biking lanes to reduce interaction with motorized traffic.
3. Gradient of the Road: The steepness of routes, with flatter gradients preferred for ease of travel and reduced physical strain.
4. Traffic Volume: Safe road conditions, with low traffic volumes being essential for a safe and comfortable bicycling experience.

These factors were chosen based on survey responses, reasons cited for not using bicycles as a mode of transport, and key considerations influencing route preferences.

### 5.7. AHP Calculations

The pair-wise comparisons performed during the AHP process helped establish the relative importance of each infrastructure attribute in relation to the identified factors. The relationship between each category and corresponding factors was analyzed systematically to prioritize solutions. The results of these calculations and their implications for improving bicycle infrastructure are discussed in the following sections.

TABLE I. AHP for Categories

| Categories | | | | | |
|---|---|---|---|---|---|
| | **Consistency** | **Directness** | **Comfort** | **Attractiveness** | **Relative Weight** |
| **Consistency** | 0.14 | 0.11 | 0.14 | 0.27 | 0.17 |
| **Directness** | 0.49 | 0.40 | 0.46 | 0.21 | 0.39 |
| **Comfort** | 0.31 | 0.27 | 0.31 | 0.40 | 0.32 |
| **Attractiveness** | 0.06 | 0.23 | 0.09 | 0.12 | 0.12 |

TABLE II. AHP for Consistency

| Consistency | | | | | |
|---|---|---|---|---|---|
| | Secured Parking Spaces | Number of Biking Lanes | Gradient of Road | Traffic Volume | Relative Weight |
| Secured Parking Spaces | 0.10 | 0.10 | 0.10 | 0.07 | 0.09 |
| Number of Biking Lanes | 0.48 | 0.51 | 0.59 | 0.43 | 0.50 |
| Gradient of Road | 0.19 | 0.17 | 0.19 | 0.31 | 0.22 |
| Traffic Volume | 0.24 | 0.22 | 0.12 | 0.19 | 0.19 |

TABLE III. AHP for Directness

| Directness | | | | | |
|---|---|---|---|---|---|
| | Secured Parking Spaces | Number of Biking Lanes | Gradient of Road | Traffic Volume | Relative Weight |
| Secured Parking Spaces | 0.11 | 0.11 | 0.13 | 0.10 | 0.11 |
| Number of Biking Lanes | 0.30 | 0.29 | 0.29 | 0.30 | 0.29 |
| Gradient of Road | 0.30 | 0.34 | 0.34 | 0.35 | 0.33 |
| Traffic Volume | 0.30 | 0.25 | 0.24 | 0.25 | 0.26 |

TABLE IV. AHP for Comfort

| Comfort | | | | | |
|---|---|---|---|---|---|
| | Secured Parking Spaces | Number of Biking Lanes | Gradient of Road | Traffic Volume | Relative Weight |
| Secured Parking Spaces | 0.08 | 0.05 | 0.07 | 0.11 | 0.08 |
| Number of Biking Lanes | 0.25 | 0.16 | 0.10 | 0.18 | 0.17 |
| Gradient of Road | 0.25 | 0.32 | 0.21 | 0.18 | 0.24 |
| Traffic Volume | 0.42 | 0.47 | 0.62 | 0.54 | 0.51 |

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TABLE V. AHP for Attractiveness

| Attractiveness | | | | | |
|---|---|---|---|---|---|
| | Secured Parking Spaces | Number of Biking Lanes | Gradient of Road | Traffic Volume | Relative Weight |
| **Secured Parking Spaces** | 0.12 | 0.07 | 0.10 | 0.16 | 0.11 |
| **Number of Biking Lanes** | 0.24 | 0.13 | 0.13 | 0.12 | 0.15 |
| **Gradient of Road** | 0.29 | 0.27 | 0.26 | 0.24 | 0.26 |
| **Traffic Volume** | 0.35 | 0.53 | 0.51 | 0.48 | 0.47 |

TABLE VI. Overall and Relative Weights

| Factors | Overall Relative Weight |
|---|---|
| Secured Parking Spaces | 0.10 |
| Number of Biking Lanes | 0.272 |
| Gradient of Road | 0.274 |
| Traffic Volume | 0.36 |

| Category | Relative Weight |
|---|---|
| **Consistency** | 0.17 |
| **Directness** | 0.39 |
| **Comfort** | 0.32 |
| **Attractiveness** | 0.12 |

TABLE VII. Ranking based on Factors

| Rank | Factors | Overall Relative Weight |
|---|---|---|
| 1 | Traffic Volume | 0.36 |
| 2 | Number of Biking Lanes | 0.27 |
| 3 | Gradient of Road | 0.27 |
| 4 | Secured Parking Spaces | 0.10 |

The Analytic Hierarchy Process (AHP) analysis helped establish a weighted ranking of the factors critical to effective bicycle infrastructure planning. This ranking provides clarity on priorities for addressing barriers and promoting safer and more efficient cycling at the University of Texas at Austin campus.

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### 5.8. Ranked Factors Based on Weight

1. Traffic Volume - Traffic volume emerged as the dominant factor across multiple studies and survey responses. Its recurring significance underscores its role in creating safe and accessible biking infrastructure. Cyclist safety must be a core focus in planning and policymaking, with initiatives aimed at reducing interactions between bicycles and motor vehicles on high-traffic routes.
2. Number of Biking Lanes - The provision of additional biking lanes is the second most important factor. Expanding and connecting biking lanes can encourage more students to adopt bicycles as their primary mode of transport. This improvement will enable cyclists to avoid congested areas, navigate routes with reduced traffic volume, and enhance access to locations not currently integrated into bicycle route maps.
3. Gradient of the Road - Road gradient ranked third, as the ease of travel significantly influences student decisions. Flatter gradients are preferred for their ability to provide effortless commutes to campus. Addressing this factor is essential for ensuring accessibility and minimizing physical strain, particularly for longer commutes.
4. Secured Parking Spaces - The availability of safe and theft-proof bicycle parking spaces ranked fourth. Frequent bicycle theft incidents and the moderate cost of purchasing a bicycle deter students from cycling. Developing secured parking facilities would provide cyclists with the confidence and convenience necessary to integrate bicycles into their daily commute.

The AHP analysis reinforces the significance of these factors in planning and maintaining effective bicycle infrastructure. By addressing these priorities—particularly traffic volume and biking lanes—universities and policymakers can create safer and more accessible environments for cyclists. This, in turn, will encourage sustainable transportation practices and reduce reliance on motorized vehicles, contributing to environmental conservation and public health goals.

## VI. CONCLUSION

This study identifies and addresses key challenges faced by individuals biking around the University of Texas at Austin campus, drawing on insights from the literature review, case study, and survey. The analysis highlights pressing issues such as unsafe road conditions, inadequate cycling infrastructure, and the absence of secured parking spaces. Using the Analytical Hierarchy Process (AHP), potential solutions are suggested to mitigate these challenges while considering the interplay of various factors and variables.

Establishing a clear and focused goal is essential, as bicyclists have differing infrastructure preferences, which may lead to varied or biased results. Narrowing the scope of planning ensures that efforts are directed toward the most pressing issues and opportunities. Collaboration with the city to provide enhanced bicycle facilities and stronger connections to the campus is crucial for fostering a safer and more accessible environment for cyclists.

While this study provides valuable insights, there are inherent limitations in the methodology and data collection. The small sample size of the survey, combined with generalized findings based on literature reviews and case studies, may restrict the scope and reliability of the results. Further research, supported by a detailed life cycle cost analysis, is necessary to explore these challenges comprehensively. This would allow for the inclusion of additional variables such as asset management, resilience, reliability, interdependencies, and sustainability metrics.

Despite its limitations, this study serves as a strong foundation for future research, offering a practical framework for developing robust and optimal solutions to bicycle infrastructure challenges. It emphasizes the need for informed and inclusive planning practices to create a more sustainable and cyclist-friendly campus environment.

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