# Approaching Bicycle Infrastructure and Policy in The United States

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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## Introduction

The very first bicycle was invented by Karl von Drais in 1817. The original model consisted of a considerable 50-pound frame along with two wheels, which were propelled by pushing off the ground with one's feet and without the use of pedals (Andrews, 2018). Obviously, since then, bicycle technology has evolved immensely. However, with the introduction of the first automobile in 1885 by Karl Friedrich Benz, bicycles were soon surpassed by the gas combustion substitute (History.com Staff, 2012). In 2016, there were 47.5 million cyclists/bike riders and 222 million car drivers in the United States (Gough, 2018; Wagner, 2019). This statistic points to the inherent difference between bicycle and car ridership in the United States.

Throughout their history, automobiles have exhibited continuous improvement and evolution, meanwhile, due to a bicycle's simpler technology and function, there appears to be less room for improvement. Fortunately, due to a bicycle's simplicity and source of power, a strong case can be made for a bicycle as an environmentally sustainable alternative to fossil fuel powered automobiles. However, for a variety of reasons, bicycles have failed to maintain a competitive market share in the United States. While some of these reasons may be due to social factors, the technical limitations of speed, endurance, safety, and comfort all areas in which bicycles can and should improve. These are complex engineering challenges, but there are many ways to approach these issues. Thus, for the technical project, the team is competing in a human powered vehicle (HPV) competition, seeking to inspire mechanical engineers and promote innovation and improved function in the bicycle and greater human powered vehicle industry.

It is obvious that a product with excellent technical performance does not always guarantee mainstream success. Even if the function of a bicycle is greatly improved, there are

other factors that must be considered that contribute to the product's commercial success. A successful implementation of bicycles depends on multiple parties: bicycle manufacturers, infrastructure developers, and rides. Bicycle manufacturers are particularly involved in the technical side of bicycle's success. Riders and policy makers, on the other hand, are stakeholders that have the power to control the bicycle market. Federal and local policies have a great potential for affecting the automobile-dominated transportation market and the effects of policy changes are worth exploring. Human powered transportation is promising for a variety of reasons. From a public health perspective to existing as an environmentally sustainable alternative to other forms of fuel-powered transportation, bicycles appear to be grossly underutilized. As a nation, the United States is responsible for providing its citizens with transportation access and must further consider what investments in bicycle infrastructure will provide societal benefits.

**Case Context**

By improving and innovating existing human powered vehicle technology, the hope is that demand for these methods of transportation would increase, due to a variety of potential benefits. The human powered vehicle technical project challenges the team to design a vehicle that is easy to use, aesthetically appealing, fast, durable, safe, and much more. Each of these attributes are incentives for an increased public adoption of HPVs. However, technological innovation alone will not instigate a transportation revolution. According to Handy et al. (2010), the attitudes and preferences towards bicycling are multifaceted and highly varied from person to person. After conducting surveys in various cities, they were able to draw conclusions correlating regular bike usage with other factors such as education level, bicycle infrastructure,

and perceived social value. Provided the great environmental implications of gas-combustion vehicles, a small shift of just 5% of short vehicle trips would have an immense impact on reducing a community's carbon footprint (Lindsay et al., 2011). Environmental concerns are everyone's concerns—it can therefore be acknowledged that other stakeholders, such as policy makers, have a vested interest and even responsibility to aid in the implementation and success of bicycle technology.

In addition to the immense sustainability motives, an increase in bicycle ridership may result in other indirect benefits. A theoretical simulation completed by Thomas Blondiau et al. projected that a doubling of bicycle ridership in the European Union would lead to an increase in jobs in the cycling industry by over 60% (Blondiau et al., 2016). Analysis of phone location data concluded that cyclists in cities commute faster than cars and motorbikes, due to improved transportation efficiency provided by bike lanes (Reid, 2018). Further, riding a bicycle has health benefits—given they require movement for operation, public health and bicycle popularity have a directly corelating relationship. Lastly, bicycles are overwhelmingly cheaper than cars to own, with little to no costs of ownerships. Thus, bicycles allow for more fair access to transportation methods.

**STS Topic**

With the introduction of the original bicycles, different social groups applied different meanings to the technology. With these meanings, they created their own requirements for what would be considered a fulfilling bicycle. Some groups sought the speediest bicycles, whereas others prioritized safety. This multi-directional growth of the bicycle is fed through the Social Construction of Technology framework, which argues that society steers technology (Pinch and

Bijker, 1984). Societies shifting preferences and concerns can lead to this framework operating in a dynamic manner over time. As transportation methods in both urban and rural areas have expanded to integrated and sophisticated networks of multiple modes, there has grown to be somewhat of a competition for infrastructure. For example, the dominant automobile has driven the development of an intense and largely accessible network of roads. Through the Actor Network approach, Bruno Latour expands upon the conditions proposed in the Social Construction of Technology framework, adding that artifacts, or the technology itself, is capable of pushing back on people through its physical structure and function (Latour, 1992). Through this theory, all forms of technology and all of society exists in an interwoven network, where each has a direct or indirect effect on each other. Given this concept, along with the idea that bicycles are their own independent technology, bicycles do not function in the same way as combustion vehicles. For this reason, bicycles must be granted an individualized and unique forms of infrastructure development and implementation, understanding the technological and societal context in which they are placed.

To supplement bicycle technology as a form of transportation, a variety of stakeholders, artifacts, and actors are involved in bicycle implementation and success. The Actor Network Theory framework supports the idea that although bicycles and automobiles share many common stakeholders, each possess their own independent stakeholders. For example, bicycles, given the nature of their technology, are limited by the health of the user. On the contrary, automobiles are less discriminatory towards the physical condition of the user. Through the many ways the technologies are limited in their function, they create their own unique stakeholders. However, just as how the Actor Network Theory and symmetry discuss how technology pushes back on humans, it is important to also consider how these two technologies interact and push back on

each other. The most obvious example of this discussion is infrastructure when acknowledging the frequency at which bicycles and automobiles must coexist on public roads. There are a variety of social and technical factors that drive interests in bicycle transportation and they are worth investigating. Technological innovation can only do so much- social and political changes drive the success of technology. Finding ways to improve up bicycles and human powered vehicles is of great interest and value, however, to meet sustainability and health related public goals, many other factors must be considered.

**Research Question and Methods**

The United States faces a challenge in that it struggles to find the same demand for bicycles as found in many other countries such as Denmark, Germany, and Netherlands. In 2007, Pucher and Buehler completed case studies investigating cycling policy in several cities in these countries. From the investigations, they found that common characteristics among these cities include an emphasis on safety, rider comfort, bicycle parking, and public education and promotional events (Pucher & Buehler, 2008). Each of these elements correlate with an increased share of bicycles in the transportation sector. Thus, to counteract the transportation imbalance the United States currently holds, policy actions must be taken. For this reason, this research sought to answer the question: What bicycle infrastructure and policy strategy should the United States pursue in order to increase bicycle ridership?

The primary approaches to answering this question were through case studies and policy analysis. A diverse list of policy, infrastructure, and programming methods were the foundation for the case studies chosen for this paper. For each mean, or intent, of improving bicycle ridership, at least one example was found assessing its effectiveness and/or outcomes. To gather

this information, transportation policies and infrastructure in other countries were assessed and compared. Academic research journals provide impact analysis on the many different forms of bicycle facilities. Looking at policies from cases with both high and low ridership allowed for an in-depth comparison of finding common denominators in areas with successful bicycle infrastructure. On top of analyzing foreign policy, it was important to have a thorough understanding of the political, geographical, and social environments presented in the United States. It must be understood that successful policy in one country or municipality may be a failure in another. In the United States, current federal transportation budget allocations consist of little direction and motivation for bicycle infrastructure (Handy & McCann, 2010). This often results in municipalities needing to creatively finance cycling infrastructure through resources such as crowdfunding, bonds, donors, tax incrementing, and impact fees (Miller & Coutts, 2018). On the other hand, it is important to acknowledge negative unintended implications of bicycle infrastructure spending. Preliminary background research showed that previous American bicycle infrastructure development has perpetuated gentrification in cities such as Chicago and Portland (Flanagan et al., 2015). Thus, it is important to consider the implications while gathering policy reform options. Through completing comprehensive studies and policy analysis, a policy recommendation can be made, noting the expected benefits to follow such reformations.

## Results

The United States for many reasons, pales in comparison to many other developed nations on the planet when it comes to bicycle enthusiasm, ownership, and ridership. The most bicycle friendly of cities in the United States only see 5 or 6 percent of their commuters riding bicycles to work. Meanwhile, European cities like Amsterdam and Copenhagen exhibit a modal

share of cycling commuters between 30 and 40 percent (Rosenthal, 2011). This phenomenon can be attributed to many reasons and is complex to diagnose. American unpopular sentiment towards commuting via bicycle is often founded in the fear of safety risk, lack of knowledge, and access to other, more familiar transportation options. To tackle many of these issues, the nations and localities who have exhibited greater cycle ridership have given greater prioritization towards infrastructure and development. From the federal to local level, understanding the context is essential for bicycle infrastructure success. Overall, the failure of the United States to draw respectable attention towards bicycles stems from two key interwoven causes: unsatisfactory transportation facilities and misdirected American bicycle culture.

The current cycling environment in the United States is weak, notoriously so, for a variety of reasons. In 2018, a survey conducted by Corona Insights and commissioned by PeopleForBikes asked 21,896 United States citizens about their bicycling experience and habits. The responses led to many interesting findings. To start, bicycling is particularly uncommon, with only 32% of Americans rode a bike at least one day in the timeframe of one year. Fifty percent of adults would like to bicycle more, but are worried about being hit by a motor vehicle. Forty eight percent of adults believe that bicycles are "a convenient place to get from one place to another" (Herndon, 2019). These survey results indicate important details regarding the current environment surrounding cycling in the United States.

The United States has grown particularly notorious on a global level for existing as a highly developed nation, but being so dependent on automobiles as a mode of transportation. All throughout the internet, countless blogs and threads show Americans and foreigners comparing their vastly different cycling experiences in their international experiences. The most common observation made is that the societal approach towards bicycling is fundamentally different

between different places. One person claimed, “The main difference between the US and the Netherlands is that cycling is not seen as transportation in the US by the general public” (“US cycling from a Dutch perspective,” 2013). This and similar viewpoints are frequently found amongst Europeans, speaking to the underlying cause of the American cycling failure.

Through creating a list of policy, infrastructure, and programming means for increased bicycle ridership, case research has been conducting, highlighting the results of these measures and the means for implementation. This information has been compiled into a figure (see Fig. 1) and many ideas are further elaborated on in paragraphs to follow.

| Measure | Description | Case Example | Measured Case Results |
|---|---|---|---|
| On-Road Bicycle Lanes | Typically designated by a stripe on the pavement splitting automobile and bicycle traffic | Commonplace in the United States and all around the world, these are are lower cost infrastructure additions (Groot, 2016). | Between 2007 and 2010, crash-sites identified by the Iowa Department of Transportation observed a decreased crash risk of up to 60% in locations with an on-road bicycle lane (Hamann & Peek-Asa, 2013). |
| Off-Street Paths | Two-way paths and/or trails that are disconnected from motor vehicle traffic and roadways | Commonly found in U.S. cities, but limited in mileage (Bicycling Bicycling & Walking 2018 Benchmarking Report, 2018) | In King County, Washington, separate off-street paths were correlated with an increased ridership (Moudon et al., 2005). |
| Shared Lane Markings | Indicate a roadway as mixed use for both motor vehicle traffic and bicycle traffic | Seen primarily in the United States, this low cost tool (Weigand et al., 2013) first appeared in the Denver in the 1990s. | The city of Chicago showed a very little increase in ridership and an increase in injury risk due to shared lanes (Ferenchak & Marshall, 2016). |
| Cycle Tracks | Similar to on-road bicycle lanes, however, these include a physical separation such as a curb or fence | Relatively common in Europe, less common in the United States (Guide for the Development of Bicycle Facilities, 2012). There were 29,000 kilometers of cycle tracks in the Netherlands in 2013 (Lusk et al., 2013). | In Copenhagen, Denmark, cycle tracks increased bicycle traffic mileage and decreased motor vehicle traffic mileage (Jensen, 2008). |
| Bicycle Boulevards/Fietsstraats | Motor vehicle-legal roads that prioritize bicycle traffic with low speed limits, speed bumps, and diverters | These facilities are named differently in different countries. The Netherlands refers to them as Fietsstraats, meanwhile, they are slowly becoming more popular in the United States, where they are referred to as bicycle boulevards and were first seen in Berkely, California. | Studies are not widely available regarding these facilities, however, it is understood that quiet and low-traffic streets are particularly preferred for inexperienced riders, women, and children. |
| Bicycle Stations | Full-service facilities offering secured bicycle parking and maintenance | Utrecht, Netherlands hosts the worlds largest bicycle station (Boztas, 2019). | |
| Bicycle Sharing | Short-term bicycle rental systems with conveniently located stations for pick-up and drop off | Hangzhou, Chine hosts the world's largest short-term bicycle sharing system. | |
| Bicycle Education | Includes rider training, awareness programming, and increased knowledge of bicycle laws | Starting at a young age, the Dutch, German, and Danish receive bicycle training as part of the school curriculum (Pucher & Buehler, 2008). | |

Table 1. Highlighted Case Examples of Policy, Infrastructure, and Programming Initiatives

Shared Lane Markings, often casually referred to as “sharrows”, are arrow markings on a traditional automobile road that indicate that the road is a shared road, for both vehicles and bicyclists. First appearing in Denver in the 1990s, this form of traffic tool is primarily only found in the United States and is growing increasingly common (McEntee, 2018). The American Association of State Highway and Transportation Officials proposes the purpose and potential benefits of signing and marking for a shared roadway. Signage alerts motorists of the possibility of nearby bicyclists, who are often difficult to see, which otherwise would often lead to near misses or road accidents (*Guide for the Development of Bicycle Facilities*, 2012). Sharrows are often implemented in situations where city planners or engineers intend to keep existing roadways, but are still seeking some sort of bicycle facility. The City of Portland estimates a standard sharrow to cost $250 for materials and installation, compared to conventional bike lanes, which provide exclusive spaces for bicyclists adjacent to moto vehicle traffic and are estimated at $3 per foot (Weigand et al., 2013). In Chicago, a study showed that the implementation of sharrows led to a very little increase in bicycle commuters and that they also exhibited more injuries over time when compared to city blocks without any bicycle infrastructure installed (Ferenchak & Marshall, 2016). Many American cities are making many attempts to engineer a culture of bicycle commuting. Various forms of bicycle lanes, paths, and tracks are being developed throughout, however, on the whole, bicycle infrastructure spending is less in the United States when compared to nations with high ridership. Americans are overwhelming dependent on automobiles- in 2017, there were 838 motor vehicles per 1,000 people, far surpassing any mentioned nations with particularly successful bicycle infrastructure (*State Motor-Vehicle Registrations—2017,* 2019). The United States has an inherent, yet

complicated, dependence on cars, further adding to the difficulty in pursuing greater bicycle usage.

Netherlands and Denmark are rightfully regarded as two of the most bicycle friendly countries on the planet. Infrastructure in these places is abundant, demonstrating a dedicated focus on appealing to the needs of cyclists. Expectedly, infrastructure does come with a high cost. However, in places like Netherlands, resources are provided at multiple levels. Forty percent of investment in cycle infrastructure comes for the Dutch central government, with regional and local levels providing the rest (Reid, 2018). This funding is important for many reasons, but is particularly of value because it represents that the country as a whole is involved in the mission towards sustainable transportation, promoting a strong bicycling culture throughout the country.

Various investments by these and other bicycle-heavy countries have pointed to particularly successful forms of cycling infrastructure and facilities. One common type of bike lane is known as a cycle track. Cycle Tracks function very similarly to a conventional bike lane, however, they are distinguished by a form of physical separation between the bike lane and the motor vehicle road, which often exists as a curb or physically barrier. In Copenhagen, a study showed that the construction of cycle tracks resulted in a 20 percent increase in bicycle traffic mileage and a 10 percent decrease in motor vehicle traffic mileage (Jensen, 2008). In 2013, there were 29,000 kilometers of cycle tracks in the Netherlands (Lusk et al., 2013). The increased safety provided by these lanes has led to well known benefits, however, the United States has failed to encourage them. The American Association of State Highway and Transportation Officials does not mention cycle tracks once in their 2012 guide (*Guide for the Development of Bicycle Facilities*, 2012). Beyond cycle tracks, there are many other types of facilities provided

to cyclists. Fietsstraats in the Netherlands are roads that prioritize cycle traffic through low speed limits and speed bumps, however, they do allow for vehicle traffic. Alternative solutions like this allow for bike riders to feel safer, while making it so existing road infrastructure does not have to be greatly changed. In Utrecht, Netherlands, the world's largest bicycle station was built, allowing cyclists to store their bicycles safely and easily, and allowing for easy access to the public rail system (Boztas, 2019). And one final example of innovative bicycle facilities: Hangzhou, China has developed the world's largest short-term bike sharing system, alleviating concerns over theft, vandalism, and parking space.

Further, in terms of programming, there was is one program in particular that demonstrated value repeatedly. Countries around the world are demonstrating innovative solutions that improve biker experiences and increase ridership. At a young age, Dutch, Danish, and German receive extensive bicycle training as part of their school curriculum (Pucher & Buehler, 2008). Beyond infrastructure, policy measures encouraging bicycle familiarity and safety are important to consider.

**Discussion**

While discussing means and measures to increase bicycle ridership in the United States, it is important to acknowledge the intent of the goal, but also understand the limitations of the process. The Social Construction of Technology theory describes the reason by which the technology and improvements to infrastructure have come to be: bicycles provide an affordable, environmentally sustainable, and physically engaging means for transportation. However, Latour's Actor Network Theory acknowledges that technology has its limitations (Latour, 1992). As seen in the United States, there has been a cultural failure to normalize bicycle transportation.

The reliance on automobiles is greatly to blame for this phenomenon. Humans put bicycles into context and comparison with motor vehicles, thus when the artifacts are compared, it is up to humans to interpret how these technologies are utilized. Ignoring the reality of the situation, commuting via bicycle is often thought of as a burden in the United States. Given how accessible cars have become, it has grown to convince people otherwise. By constructing technology that makes bicycles more appealing, this interpretation may improve, however, this technology will always be held back by the way in which the culture of cycling informs how people approach it.

The research and analysis presented in this these are limited by the scope. The United States is a large country, with vastly diverse geographic, economic, public health, and political landscapes. There cannot be one simple solution to solve the failure of bicycles in the United States. Each municipality and region must be approached individually, to analyze the problem given the specific context presented to that place. Thus, any conclusions made in this paper are more theoretical than actionable. In future approaches to this problem, it would be more effective to approach specific regions or localities to provide insights.

In reality, technology and policy do not always prove to meet intent. The world is intricate, and there are many complex factors that may contribute to the failure to produce expected results from an action. As discussed in this paper, the United States has made efforts to encourage bicycle use, however, the outcomes have been limited. The way persons respond to technology and innovation is difficult to predict, although it must be considered. Before allocating resources towards a project, it is essential to consider and predict the outcomes. Technology may function as hoped, however, how people interpret said technology is the gauge for a technology's success.

Through research, I have come to both appreciate and understand the imperativeness of this matter. Bicycles are the healthiest and most sustainable form of transportation technology that exists on this planet, at least at a mass scale. As an engineer, I understand the interconnectedness of technology. Bicycles must coexist with other forms of transportation, such as automobiles and public transit. As I continue in my engineer practice, regardless of the field, I will take this understanding and mindset and apply it to my work. The technology that I develop and interact with does not exist independently. It has an effect on us and other technology, making the small details that much more important. And in general, this work has taught me the value of sustainability, public investment, and health. Technology can carry meaning and good intent, and that is one of the main reasons I have decided to pursue engineering.

**Conclusion**

As an issue of both infrastructure and culture, the issue cannot be solved by tackling either independently. It is important to invest more in technology, infrastructure, and education, as seen in many other successful cases, but it is also important to understand the cultural context of the United States. Bicycles prove to be effective modes of transportation, but for many Americans, the benefits are not clear or the drawbacks are too high. The desire to increase bicycle ridership in the United States is driven from issues in health, sustainability, and equality. Out of virtue, leaders of the United States, as well as city planners, policy makers, and engineers have a responsibility to understand the power that bicycle transportation has, and how beneficial it could be for not only the United States population, but for the world: to better the health of riders, to reduce emissions, and to improve access to transportation for many. The United States is falling behind many other advanced and developed nations in each of these

areas. The transportation industry, especially bicycle transportation, can have great positive benefits. The United States must understand in order to drive a systematic push towards sustainable living, there must be a concerted effort of technological investment, education, and reconsideration of the way Americans approach transportation as a whole.

Going forward, it is important to understand the motivation of this work. I am not encouraging bicycle usage simply because it can be enjoyable. Bicycles are an excellent way to reduce one's carbon footprint. Riding one for a daily commute can bring immense physical and mental health benefits. The improvement of bicycle infrastructure creates a more safe and reliable form of transportation for those who cannot afford a more expensive alternative. However, for awareness to spread, the incentives of bicycle ridership need to continue to grow and be more visible. With this, a positive feedback loop is presented: bicycle infrastructure and policy development will be most pressured to improve when demand increases. When demand increases, more will recognize the benefits and demand will further increase. Thus, as engineers, advocates, and citizens of the United States, the most valuable thing you can do is to implement bicycle transportation in your daily life and to help spread the message around the United States. With that goal, we can hope to see a more sustainable and healthy future.

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