Prospectus

Human Powered Vehicle Machine Design
(Technical Topic)

Effects of Bicycle Infrastructure Policy Reform in The United States
(STS Topic)

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 without the use of pedals by pushing off the ground with one's feet (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 technology 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 Vehicle Machine Design Project

The Human Powered Vehicle Project challenges fourth-year mechanical engineers to design and build their own HPV. A human powered vehicle derives energy for propulsion from human muscle power. The direct purpose of this project is to enter a finished project into the American Society of Mechanical Engineering (ASME) Human Powered Vehicle Challenge. The competition scores entries in multiple events. Each event is scored through a combination of judges' ratings and performance metrics. First, a design report including documentation of the design process must be submitted along with videos summarizing the vehicle's safety and technological design. The vehicle is then scored on performance in a speed event and an endurance event (American Society of Mechanical Engineering, 2019). Overall, the project forces the team to consider the value in nonmotorized transportation and particularly challenges the team to investigate novel ways to improve and innovate current human powered vehicle technology. And while completing the project, it is important the team is intentionally detailed in documentation, as the competition heavily values a thorough design report. Success or not, the project and competition seek to inspire innovation in sustainable human powered vehicles. Although the vehicles designed for the competition aren't commercially available, the technical project forces critical thinking about transportation alternatives and may pique the interest of aspiring engineers to pursue a career in the human powered vehicle industry.

The general time outline for the project, as assigned by the course instructor, is inspired by the design process as discussed in Robert L. Norton's *Design of Machinery*. The design process includes: background research, identifying a goal statement, defining performance specifications, generating design ideas, completing design analysis, creating a detailed design, prototyping and testing, and lastly, final production (Norton, 2012). It is possible, however, that some stages may be completed simultaneously due to time and budgeting constraints. Regardless, it is important to carefully consider this model, as without it, details may be easily overlooked and objectives may not be met. At the start of the project, the team began by completing research on competition rules and exploring past design reports from other teams. The competition rules are particularly set to improve safety of riders and pedestrians. Mandatory components of all competing vehicles include a harness system, a durable rollover protection system, and visible and audible alerting systems, such as horns and headlights. By investigating former competition entries, preliminary design inspiration could be gathered for how to meet these requirements. Next, the team sought to define their goals: to design and build a build a human powered vehicle that performs well in the competition, complimented with a well-documented research process.

Through design ideation, which was driven by team research on past designs as well as research in manufacturing methods and materials, multiple designs opportunities were proposed. The largest decisions to be made were number of wheels (bicycle, tricycle, or quad) and whether there would be a fairing to reduce vehicle's aerodynamic drag. To improve the project's efficiency, the team was split up into two core functional groups: frame and drivetrain. And within these groups, sub teams have been developed and assigned in order to even further delegate tasks and allow individual persons to specialize in specific components of the vehicle. With further investigation, analysis, and testing, a final design will be established.

The project will be driven by several resources. Design reports from former competitions are archived on the Human Powered Vehicle Competition website. Academic resources are to be utilized to optimize vehicle biomechanics, material decisions, and drivetrain design. Once the design is developed utilizing computer-aided design software SolidWorks, the vehicle is to be constructed. The team has access to Mechanical Engineering Professor Shawn Russell's lab, which offers various devices for measuring human biomechanics, which is valuable for testing ergonomics and biomechanical efficiency. The team has access to the Lacy Student Experiential Center, which offers equipment and space for tasks such as CNC tooling, milling, cutting, and welding. Some materials will be provided by the lab, while others will need to be purchased utilizing the $2,000 the team has been provided by the course. In preliminary research, it has been found that former teams have held budgets as high as $15,000 for their vehicle. Thus, it is to be expected that more funds will be applied for from various resources in the university community. With these many resources, the project team hopes to accomplish the goals of developing a working and successful human powered vehicle that models a sustainable future in transportation.

Bicycle Infrastructure Policy Reform in The United States Project

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.

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). Bicycles simply 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.

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 discusses 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

As mentioned, 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 (Purcher and Buehler, 2007). 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 will seek to answer the question: What bicycle infrastructure policy reforms should the United States explore and what are the benefits?

The primary approaches to answering this question will be through case study exploration and policy analysis. Transportation policies in other countries will be assessed and compared, at both the federal and local levels. By looking at policies from countries with both high and low ridership will allow for an in-depth comparison of finding common denominators in areas with successful bicycle infrastructure. On top of analyzing foreign policy, it is 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 (McCann and Handy, 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 and 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., 2016). Thus, it is important to consider the implications while gathering policy reform options. Once the comprehensive global and local case studies and policy analyses have been completed, a policy recommendation will be made, noting the expected benefits to follow such reformations.

Conclusion

The work for the STS thesis will be conducted over the 2020 Spring Semester. Throughout January, efforts will be focused on compiling case studies on bicycle policy and ridership in both foreign countries as well as in the United States. In February, understanding the current environment for bicycle infrastructure in the United States will be the priority. In March, work efforts will be focused on synthesizing the information and drawing conclusions. Lastly, in April, a substantive draft of the thesis will be written.

For the technical project this semester, designing and modelling it to take place. Parts will be ordered so they will have arrived by the start of the 2020 Spring semester. All necessary manufacturing trainings will be completed this semester. Drivetrain testing will be completed in November 2019. A preliminary design report is to be completed by November 25th, 2019. In the 2020 Spring Semester, construction of the vehicle is to be completed, as well as any necessary vehicle testing. The final design report and the vehicle are to be submitted for the competition on April 24th, 2020.

These two projects to be completed throughout this school year each seek to highlight the benefits of human powered transportation. The technical project challenges the design team to explore innovative opportunities to expand on existing human powered vehicles. The STS research supports the technical project in that this technology will not optimally function without the many social and political stakeholders. United States policy makers must be aware of the influence they have over the bicycle industry. Human powered transportation is more accessible, more sustainable, and better for public health. The thesis will outline recommended policy reformations that the United States must make regarding bicycle infrastructure and will discuss the projected benefits these reformations will result in.

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