Recumbent Vehicle Design and Entry for the 2020 ASME Human-Powered Vehicle Challenge
(Technical Paper)

Representation and Equity Outcomes of Cycling Advocacy
(STS Paper)

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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

In recent years, introducing cycling infrastructure in dense urban areas has become a valuable method of alternative transportation used to reduce pressures of living in crowded spaces such as traffic congestion, environmental concerns, and safety concerns (Federal Highway Administration, 2012). As cities are increasing investments in cycling infrastructure networks as an approach for improving health, wellbeing, safety, and mobility of groups without access to cars, it is important to consider the effectiveness and equity outcomes of these new technologies.

My STS research topic focuses on the impact of current cycling advocacy attributes on the equity of cycling infrastructure outcomes and evaluation techniques. My technical research capstone research topic is to design, build, and race a human-powered vehicle at the American Society of Mechanical Engineers (ASME) Human-Powered Vehicle Challenge in April 2020. Our technical project group will manufacture and design a recumbent tricycle as a viable, practical, and sustainable replacement for using a car in urban areas.

Technical Topic

Goal and Overview

The ASME Human-Powered Vehicle Challenge objective is to:

> provide an opportunity of engineering students to demonstrate application of sound engineering principles toward development of practical, efficient, and sustainable human-powered vehicles (American Society of Mechanical Engineers [ASME], 2019).

The ASME competition requires team vehicles to pass a safety inspection, pass performance braking and turning specifications, withstand top and side applied loads, and enter sprint and endurance races. Our group has developed an additional self-imposed goal: to build and design a human powered vehicle that exemplifies the qualities of speed, safety, sustainability, durability, accessibility, and user-friendliness. Our design is aimed at users that cannot ride a traditional upright bike and wish to substitute use of a car to travel in urban areas.

Significance

Equipment choice changes the comfort, convenience, safety of cycling, and can affect an individual's decision to cycle (Handy et al., 2013). New cycling infrastructure offers safety benefits to increase cycling rates due to passive, population-based behavior change initiatives that do not require repeated reinforcement (Winters et al., 2018). However, studies have also noted that inexperienced cyclists, risk averse individuals, women, people with children, and those with chronic health issues tend to avoid using cycling as a mode of transportation. If cities increase investments towards the safety of cycling infrastructure, lack of available cycling equipment may still prevent potential individuals from using new cycling paths. A recumbent tricycle can provide a means of transportation with designated cargo space, stable three-wheeled geometry, comfortable riding positioning, and protection from harsh weather that a typical bicycle cannot. This technical project aims to break the cycling access and cycling equipment barrier by constructing a recumbent vehicle that can meet daily cargo carrying needs and strict ASME competition safety and performance specifications, yet remain accessible to populations averse to cycling.

Technical Team Organization

The capstone team is divided into five sub-teams that control design and manufacturing of each component of the vehicle: frame, fairing, drivetrain/biomechanics, innovation, and steering. The capstone project consists of a semester-long design phase followed by a build and testing phase. We are currently researching existing recumbent trike frame geometries, materials, and drivetrain components to tailor the trike design to abilities of an average consumer while remaining competitive for the ASME races. The majority of research will be collected through a mass survey of the potential user market for our vehicle, review of current recumbent vehicle technology at recumbent bike shops in Virginia, and computer-aided simulations of prototype designs. The testing phase of the project will evaluate the ability of riders to achieve performance and safety specifications required by ASME to enter the competition and market user needs determined by the market survey. The success of the design in achieving our team's self-imposed goal statement will be evaluated by ASME competition results and comparison to market survey results.

STS Topic

Background

In North America, cycling consists of only 1-2% of trips in cities compared to 15-40% of trips in European cycling cities (Winters et al., 2018). American cities have recognized this potential for increasing cycling use and introduced new cycling infrastructure such as separated bike lanes, off-street bike racks, and marketing programs in an attempt to lessen barriers to city residents' decision to cycle. From 1991 to 2009, federal spending on cycling infrastructure has increased from $5 million annually to $1 billion annually (Pucher et al., 2011). Accessible, efficient, equitable, and safe alternatives to car travel enable everyone to walk more, travel by bicycle, expand access to economic mobility, and reduce emissions (Malekafzali, 2009). Riding a bike itself is largely accepted as a transparent mode of transportation that does not naturally warrant class or race divisions for able-bodied individuals. However, cycling culture and infrastructure networks have a history of avoiding critique by city planners. Cycling is viewed as a green alternative to driving a car that will also aid in curbing unhealthy personal habits. Safe cycling paths are primary spaces to integrate physical activity, encourage social interaction, and provided transportation links to encourage mobility in underserved communities. In turn, cycling advocates tend to seek to promote these positive elements of biking. As a result, investing in cycling infrastructure has become a trendy way for city governments aiming to promote community among residents and take advantage of cycling's benefits, but can also cause conflict among strained neighbors to fight for resources devoted to cycling amenities and further marginalize underserved populations (Hoffman, 2016). The mechanism of this conflict is closely related to the way that cycling advocates marginalize interests that exist outside of their agenda (Furness, 2010). Cyclist agendas can become slanted to include the interests of this representation.

Planned Analysis

I will explore representation in cycling advocacy and the exact mechanism of how advocacy attributes affect the changes in cycling infrastructure in North American cities and whether equity is an afterthought during this process. I will use the social construction of technology (SCOT) framework to do so. In upper and middle-class society, cycling is a form of recreation and elite sports. In lower classes where driving a car may be a status symbol, cycling carries a stigma as a poor man's vehicle with little opportunity for upward economic mobility (Pooley, 2013). These changing images of cycling through different socioeconomic areas can also feed into the mechanism cycling advocates use to promote their beliefs.

I will next examine socioeconomic representation in cycling infrastructure evaluations and reports. After cycling infrastructure is introduced, holistic evaluations of new changes are necessary to inform organizing stakeholders on the efficacy of these changes. However, some evaluation methods do not identify whether equal representation exists in the decision-making process of introducing cycling infrastructure. For example, the US Federal Highway Administration allocated $25 million annually to four major cities over five years in the Nonmotorized Transportation Pilot Program (NTPP) to calculate the impact of new cycling infrastructure in these cities and the subsequent mode shifts to cycling in 2012. Cycling infrastructure evaluated included off-street and on-street infrastructure, bike parking, and marketing/education initiatives. As a result, the Federal Highway Administration (2012) documented that these four communities together saw an estimated 36 percent increase in cycling mode share between 2007 and 2010. In addition, these pilot cities saved an estimated 1.7 million gallons of gas from 2007 to 2010 and averted 32 million driving miles. The success of such funding was evaluated using project-level and community-level groups to calculate quantitative metrics such as percent increases in cycling, changes in cycling trip purposes, and vehicle trips averted. These standards are aligned with the National Pedestrian and Bicycle Documentation Project Methodology and endorsed by Congress but some working groups in pilot cities Marin County and Columbia, MO only considered local officials, resident employers, and well-established cycling advocacy groups as stakeholders. Existing non-cyclist or non-commercial community members and were not considered. On the other hand, in pilot city Minneapolis, success of the program was evaluated by tracking increases in number of bike path users as well as cultural change in livable spaces. Though promising, the amount of resources being invested in evaluation programs such as the NTPP does not justify evaluation and continuous development using quantitative and inconsistent data alone. This optimistic and transparent aspect of the final outcomes of cycling advocacy may mask divides and equity issues in the early advocacy process. I plan to analyze whether disparate evaluation techniques may further mask and magnify existing divides in the cycling advocacy process and outcomes.

STS Framework

I will analyze reported cycling infrastructure outcomes, technology, and connection to prioritization in cycling advocacy using the social construction of technology (SCOT) STS framework. Specifically, I will use the four tenets of SCOT: relevant social groups, interpretive flexibility, principle of symmetry, and stabilization to investigate my STS topic. The success of new cycling infrastructure technology depends upon its implementation and placement and is largely influenced by social context. Socioeconomic representation in cycling advocacy determines the implementation cycling infrastructure technology (interpretive flexibility). Examining the evaluation of this implementation should consider the whether the implemented infrastructure includes marginalized groups (stabilization). I will consider the ability of relevant social groups such as transportation policymakers and community residents to achieve cycling advocacy agenda goals. Social explanations of both government-deemed failures and successes in cycling infrastructure outcomes will also be examined with SCOT principles.

Research Methods

I plan to use published case studies, review articles, and books on social factors affecting cycling advocacy to perform my analysis of outcomes of cycling advocacy. I will explore both pro-cycling and anti-cycling perspectives through books such as, *Bike Lanes are White Lanes: Bicycle Advocacy and Urban Planning* and *Bicycle/Race: Transportation, Culture, & Resistance*. I will collect data for cycling infrastructure statistics from published North American city case studies and recent federal reports on implemented cycling initiatives. These sources will provide data and a foundation for social critique of the most current cycling advocacy patterns and outcomes.

Conclusion

After completing the technical capstone project, my group hopes to have produced a practical recumbent vehicle that accommodates user-friendly features, sustainable manufacturing practices, and sound engineering design consistent with ASME performance and safety specifications. At the conclusion of my STS research project, I hope to produce a well-rounded social analysis of factors affecting cycling infrastructure implementation and evaluations. The technical and STS research projects will provide new insights into best practices for engineering cycling equipment and implementing cycling infrastructure with equity and user needs in mind.

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