

DUKE UNIVERSITY'S ALTERNATIVE TRANSPORTATION FUTURE

by

Jimmy Gilman & Hardy Almes

Dr. Elizabeth Albright, Adviser

Sustainable Duke, Client

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## **I. EXECUTIVE SUMMARY**

In recent years, domestic carbon emissions from the transportation sector have surpassed those from electricity generation. Various institutions, including Duke University, have struggled with reducing these emissions. Duke University's emissions from commuting have been on the rise since 2007 (excluding years during the COVID-19 pandemic).

Sustainable Duke and Duke's Parking and Transportation office have been examining means of increasing low emitting transportation modes through expanding and educating the Duke community about the use of existing services. This study examines graduate student knowledge of and barriers to using resources and services that support alternative transportation options. Alternative transportation is defined in this context as those modes other than private single-occupancy vehicles, and may include walking, biking, taking an E-scooter, carpooling, taking the bus, or using ride hailing services (i.e. Lyft, Uber) among other options.

The study examines literature regarding alternative transportation strategies and informational campaigns employed by other campuses and municipalities. The report also compiles interview responses from representatives from other schools about overcoming alternative transportation concerns. A survey of graduate students at Duke was also administered to understand their transportation habits and apprehensions towards alternative modes of transport in the context of the university.

The authors reviewed literature regarding community-based social marketing, which supports identifying barriers to desired behaviors. Once barriers are identified, these concerns can be addressed to better promote the behavior. The literature review also suggested that added time, a lack of safety, and inclement weather potential were primary concerns for use of alternative transportation on campuses.

Results from interviews confirmed that many actors on university campuses struggle with disseminating information on transportation services to students, although some have had success through multimedia orientation materials and informational classes on alternative modes. Other themes of these interviews suggest that it is important to focus on safety to promote alternative modes, and that pricing schemes such as paying for parking daily rather than monthly can incentivize commuters to drive alone less.

Survey results indicated that graduate student knowledge and use of most transportation services at Duke was quite low. Student responses also revealed that single-occupancy vehicle was

the most frequently used mode of respondents to commute to campus and that concerns of safety, time, and convenience were primary barriers to alternative transportation use, largely aligning with the literature review. Results also indicated that the COVID-19 pandemic may make students more likely to drive alone and use open-air forms of mobility such as walking and biking, but less likely to use modes that involve close proximity to others, such as transit or carpooling. These changes in comfort levels could have mixed impacts on the future of student mobility habits and use of alternative transportation modes. Moreover, student respondents indicated that they prefer to receive information on Duke's transportation services via student-wide e-mails compared to other modes of communication.

The results of this project will be used to develop informational materials that spread knowledge to the Duke community and address barriers to use of alternative transportation modes at the university. These informational materials will include a write-up that can be easily distributed via e-mail. These materials will link helpful resources that contain information on alternative transportation options and services at Duke and in Durham. The materials will also include maps of bicycle-friendly and bus-friendly neighborhoods surrounding Duke's campus.

The authors recommend that this research be repeated in future years, as data were collected during the middle of the COVID-19 pandemic. Although the authors are confident in their insights, completing this research in subsequent years will corroborate graduate student commuting patterns and barriers to using alternative modes as outlined in this paper. Future studies will also be necessary to evaluate the effectiveness of the developed informational materials, but if successful, these materials could serve as a blueprint for disseminating transportation information at Duke and at other campuses moving forward.

## II. Introduction

### 1. Background

Duke University's 2019 Climate Action Plan Update revealed that the university has reduced its greenhouse gas emissions by 24% compared to a 2007 baseline.<sup>1</sup> Much of this mitigation has been a result of increased energy efficiency and discontinuing of the use of coal in the university's steam plants. Moving forward, if the Climate Action Plan is implemented as recommended, the university will see an estimated 78% reduction in greenhouse gas emissions by 2024.<sup>2</sup>

However, transportation has lagged other sectors in terms of greenhouse gas reductions.<sup>3</sup> The university has engaged in various initiatives in order to reverse this trend, such as the development of a transportation demand management program, telecommuting opportunities, incorporating hybrid buses into its fleet and subsidizing transit passes for employees and students.<sup>4</sup> Despite these efforts, as of 2019 emissions relating to Duke's transportation needs are 9% greater than the 2007 baseline.<sup>5</sup>

This project aimed to address transportation emissions. It was carried out in collaboration with Sustainable Duke. Tavey Capps, Director of Sustainable Duke, as well as Jason Elliott, Assistant Director of Sustainable Duke, directly contributed to the research. Sustainable Duke has been involved in student master's projects in the past that have provided recommendations for new mobility services that would make Duke's system of transportation more sustainable. These projects have had varying degrees of success and recommendations have often gone unimplemented due to a lack of available funding from the university. These budgetary and administrative concerns have made the development of additional alternative transportation services impractical. Accordingly, this project instead focused on how Duke could leverage more impact from the services it already offers. In particular, the client wished to focus on the barriers to use of transportation resources among graduate students. It is hoped that the insights provided in this report can inform targeted attempts to break down barriers to alternative transportation use

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<sup>1</sup> Duke University, "Climate Action Plan Update."

<sup>2</sup> Ibid

<sup>3</sup> Ibid

<sup>4</sup> Ibid

<sup>5</sup> Ibid

among university affiliates moving forward, allowing Duke to reach higher levels of achievement on its transportation climate goals.

## 2. *Literature Review*

As background for this research, academic papers regarding alternative transportation use at other universities were reviewed. The project sought insights into appropriate survey design, in addition to a sampling of results from which it could hold in reference to collected data. In particular the project focused on work involving the barriers to improved pedestrian modal share on college campuses. Walking and biking (i.e., active modes) are more transferable means of transport to the university context than transit networks such as bussing which involve existing municipal mass transportation systems and other stakeholder participation to be fully implemented. By contrast, the relationship between active modes, the student body, and the university is more direct. As such, there was a broader and more comparable set of papers focused on pedestrian modes at universities, which became the focus of the literature review gave the study a wider context from which to approach an analysis. However, the broader literature regarding barriers to alternative transportation beyond the university context was also surveyed to provide a more complete picture. A secondary goal was to gain some insights into how to best conduct an informational campaign. Accordingly, a review of literature on environmental psychology was conducted as well.

Many information-intensive campaigns promoting sustainable behavior have been attempted in the past. Some of these campaigns leaned on the idea that a more informed population will behave in a more environmentally responsible manner.<sup>6</sup> However, in practice this strategy is not always an effective one. For example, workshops on residential energy conservation, while having a definite impact on local knowledge and prevailing attitudes, have not been able to alter behavior.<sup>7</sup> Similarly, a weekslong course of study in water conservation combined with a detailed booklet describing best practices did not make a dent in water consumption.<sup>8</sup> Multiple Swiss studies have shown that people's environmental knowledge and attitudes do not correlate with their environmental behavior.<sup>9</sup> Still, other informational campaigns have attempted to promote

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<sup>6</sup> McKenzie-Mohr, "Promoting Sustainable Behavior", 544.

<sup>7</sup> Ibid

<sup>8</sup> McKenzie-Mohr, "Promoting Sustainable Behavior", 545.

<sup>9</sup> Ibid

sustainability by targeting economic incentives. These campaigns have also tended to fail.<sup>10</sup> Expensive campaigns from public utilities, designed to improve residential efficiency by demonstrating money-saving technological and lifestyle changes have proven to be unsuccessful.<sup>11</sup> National attempts mandating such informational campaigns by utilities have also been implemented with meager success.<sup>12</sup> On their own, information campaigns do not seem to affect behavioral change.<sup>13</sup>

Why is it then that such campaigns tend to fail? After all, in the case of consumer goods, advertising can be quite effective.<sup>14</sup> However, changing behavior is a more substantial task as structural impediments may exist which can impede a person's capacity to make such a change. For example, a graduate student attempting to switch from driving a car to campus in favor of cycling can be stymied by distance, or a lack of safe bike routes. To better facilitate behavioral changes, this project instead turned to the concept and practice of community-based social marketing.<sup>15</sup> Community-based social marketing has shown to be effective in affecting people's transportation behavior in a variety of instances.<sup>16</sup> The process, as detailed by McKenzie-Mohr, is composed of four distinct steps:<sup>17</sup>

1. Discover barriers to the behavior you are seeking to promote and use these results to determine which behaviors to prioritize
2. Design a program to overcome these barriers
3. Implement the program
4. Evaluate the program once implemented

Such social marketing campaigns are an effective tool in decision-making as they help to push resources towards the most effective strategies.<sup>18</sup> Furthermore, in the process of uncovering barriers to behaviors, policymakers, planners, and other practitioners can determine the differences between groups who engage in these behaviors and those that do not which can further improve

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<sup>10</sup> Ibid

<sup>11</sup> Ibid

<sup>12</sup> Ibid

<sup>13</sup> McKenzie-Mohr, "Promoting Sustainable Behavior", 546.

<sup>14</sup> Ibid

<sup>15</sup> Ibid

<sup>16</sup> Cooper, "Successfully Changing Individual Behavior", 93.; Thøgersen, "Social Marketing of Alternative Modes", 372.

<sup>17</sup> McKenzie-Mohr, "Promoting Sustainable Behavior", 546.

<sup>18</sup> McKenzie-Mohr, "Promoting Sustainable Behavior", 547.

program design.<sup>19</sup> Identifying and understanding the existing barriers in place can also determine which behaviors can be effectively addressed and which cannot. Barriers that can be easily overcome, for instance, should be targeted rather than barriers that are more intractable. Similarly, the identification of barriers can help direct resources at the margins. All things being equal, barriers that involve a one-time change of behavior are simpler to overcome than ones which involve repeated change.<sup>20</sup> For example, a person who drives to campus because they do not own a bicycle is faced with a much smaller hurdle than one who drives because they live 25 miles from campus. Ultimately, community-based social marketing can be effective in a wide array of circumstances, from encouraging water efficiency in Durham, Ontario to removing organics from the waste stream in Nova Scotia by promoting backyard composting.<sup>21</sup>

The identification of barriers to a given behavioral change also has additional benefits. Once barriers have been identified, policymakers presented with similar circumstances can make use of and build on this existing knowledge to streamline their own processes.<sup>22</sup> To that end, this study reviewed the existing academic literature about overcoming barriers to alternative transportation on campuses.

The literature revealed several barriers to alternative transportation. Table 1 on the following page lists a summary of some of these barriers broken up by mode.

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<sup>19</sup> McKenzie-Mohr, "Promoting Sustainable Behavior", 548.

<sup>20</sup> Ibid

<sup>21</sup> McKenzie-Mohr, "Promoting Sustainable Behavior", 549, 550.

<sup>22</sup> McKenzie-Mohr, "Promoting Sustainable Behavior", 551.

Table 1. Documented Barriers to Use of Certain Alternative Modes<sup>23</sup>

Barriers to Cycling	<ul style="list-style-type: none"> <li>• Lack of familiarity with recreational cycling</li> <li>• Appearance</li> </ul>
Shared Barriers to Cycling and Walking	<ul style="list-style-type: none"> <li>• Lack of appropriate infrastructure (both for biking and other uses)</li> <li>• Low price of automobiles</li> <li>• Travel time</li> <li>• Traffic safety</li> <li>• Crime</li> <li>• Weather</li> <li>• Lack of fitness</li> </ul>
Barriers for Transit	<ul style="list-style-type: none"> <li>• Transit service shortcomings</li> <li>• Threats to safety</li> <li>• Complexity and inconvenience</li> <li>• Lack of social destinations</li> </ul>

### 3. Central Questions and Objectives

The authors suspected that there was a divide between availability of alternative transportation modes and resources on Duke’s campus and knowledge of those services among students. As a result, while Duke currently offers services that support biking, walking, carpooling, or taking other alternative modes to campus, it was believed that the knowledge and use of these resources was inconsistent among members of the Duke community, leading to a lower modal share. It was also hypothesized that other barriers such as safety and time deterred students from using these modes.

This project sought to identify the gaps that exist between these alternative transportation services offered by the university and the awareness and use of these services on the part of the graduate student body. A primary objective was to better understand student awareness and attitudes and whether an increase in knowledge of alternative modes of transport and supporting infrastructure would lead to increased use. The goal of the project is to create and share

<sup>23</sup> Okkels et al, “Cycle Works”, 6.; Kaplan, “Transportation Sustainability”, 180.; Akar and Clifton, “Influence of Individual Perceptions”, 5.; Cooper, “Successfully Changing Individual Behavior”, 93.: The act of cycling itself also appears to have some positive feedback loops, encouraging overall use. It seems to be the case that cycling for non-work purposes increases the likelihood that a person uses this mode of transport on his or her work commute as well. Likewise, attitudes towards cycling are shown to dramatically improve once people are exposed to it. In effect, experience in and of itself serves to lessen the severity of the barriers that may exist in peoples’ minds.: It should be noted that while some barriers are shared between cycling and walking, the degree to which they impact each mode may vary depending on the circumstances.

informational materials with graduate students in the Nicholas School of the Environment through orientation e-mails to spread knowledge of alternative transportation modes.

The one-year duration of this project makes it impossible to fully validate the accuracy of the authors’ suspicions regarding student knowledge as well as the efficacy of their informational materials. Therefore, the success of the project will likely be measured based upon future data that reveal how students are commuting to campus and whether viewing of these informational materials had an impact on mode choice. These results can serve as a blueprint for the need to inform students of the alternative transportation modes available and the need to target barriers to desired behavior patterns. A correlation between viewing the materials and increased use of services would encourage future informational campaigns on campus for students, faculty, staff, and other university affiliates.

### III. Methods

#### 1. Interviews

As part of this project, interviews were conducted with various university officials around the country. The authors sought to familiarize themselves with the barriers and other challenges faced by practitioners at similar schools to Duke in terms of geography, size, academic rigor, or other characteristics. Interviewees were selected based on recommendations from Sustainable Duke. Interview questions focused on schools’ alternative transportation resources and strategies, barriers to increasing alternative mode share, and methods for disseminating transportation information. Table 2 below lists these universities and the title of each interviewee.

Table 2. List of Universities and Titles of Interviewed Representatives

<b>Name of School</b>	<b>Title of Interviewee</b>
University of North Carolina at Chapel Hill	Chief Sustainability Officer
North Carolina State University	TDM Program Manager
North Carolina Central University	Director of Transportation and Parking Services
University of Rochester	Director of Transportation & Parking
University of Virginia	Alternative Transportation and Mobility Manager
Vanderbilt University	Executive Director of Mobility
Johns Hopkins University	Director of Transportation Services
Oregon Health & Science University	Transportation & Parking Project Manager
Colorado State University	Alternative Transportation Director
University of Washington	Marketing & Outreach Specialist

## 2. Survey

An online-based survey was conducted in the fall of 2020 that sought input from graduate students.<sup>24</sup> This survey gathered information on the topics listed in Table 3.

Table 3. Categories of the Survey Questions

Demographics	<ul style="list-style-type: none"> <li>• Age</li> <li>• Gender</li> <li>• Race</li> <li>• School</li> <li>• Degree</li> <li>• Proximity to campus</li> <li>• Method of receiving survey</li> <li>• Progress in degree program</li> <li>• Neighborhood</li> </ul>
Current Use of Transportation Services	<ul style="list-style-type: none"> <li>• Number of days per week commuting to campus by mode</li> <li>• Ownership by mode</li> <li>• Possession of transit passes</li> <li>• Possession of E-scooter accounts</li> <li>• Possession of a carsharing account</li> </ul>
Awareness of Transportation Services Offered by Duke	<ul style="list-style-type: none"> <li>• Free transit passes</li> <li>• Shower access</li> <li>• Bicycle racks</li> <li>• Bicycle repair stations</li> <li>• Discounts at local bicycle shops</li> <li>• Carpooling</li> <li>• Carsharing</li> <li>• Parking Passes</li> <li>• E-scooter discount prices</li> </ul>
Barriers to Use	<ul style="list-style-type: none"> <li>• Comfort level by mode</li> <li>• Concerns by mode</li> <li>• Impact of pandemic on comfort levels</li> </ul>
Open-Ended Response Questions	<ul style="list-style-type: none"> <li>• Suggestions for additional transportation services</li> <li>• Primary means of accessing knowledge relation to transportation at Duke</li> <li>• Preferred means of receiving information about these services</li> </ul>

<sup>24</sup> Institutional Review Board (IRB) approval (protocol #2021-0191 for reference) was received as part of this project, as the research involved working with human subjects as part of the surveys. The project qualified for exempt review from IRB, which facilitated a more rapid approval process.

Due to the circumstances brought on by the pandemic, the survey conducted as part of this project focused only on graduate students who were currently living in Durham or surrounding cities and commuting to Duke's campus. Graduate students were selected as the population because the vast majority live off-campus and rely on various transportation modes to commute to Duke. The survey was distributed to students in Duke's graduate schools via email list-servs, newsletters and social media. The authors used suggestions from connections at the Nicholas School of the Environment to reach out to administrative staff at other graduate schools to find out the best ways to contact their students. After initial survey distribution via email list-servs and social media, two follow-up reminders were sent through these modes over a three-week span to increase sample size and reach a wider range of students. Distribution only occurred once through student newsletters because the majority of these are only sent to students once each month.

Once the survey period closed, the data were cleaned prior to analysis. 441 graduate students responded to at least parts of the survey, and 398 indicated that they were currently living in Durham or the Triangle area and completed substantial portions of the survey. The analysis is limited to these 398 students. Location data were only considered if the data included valid intersections, and responses that indicated student residence distance to campus were rounded to half-mile distances if necessary.

Patterns among all graduate students relating to data on commuting behaviors, awareness of services, barriers to use, and suggestions were analyzed. Responses were cross-listed with demographic data to better understand differences between genders, number of years spent at the university, and schools at Duke. Data were graphically represented to facilitate the analysis and data dissemination.

First-year and non-first-year students were given slightly different prompts in relation to answering the survey questions.<sup>25</sup> First year students are asked to answer the questions regarding their current commuting patterns (i.e. during the COVID-19 pandemic). Non-first year students, in contrast, were directed to answer the questions regarding how they commuted before the start of the pandemic. This variation allowed the authors to interpret differences between student classes to better understand how the pandemic may have changed student commuting patterns and knowledge of transportation services.

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<sup>25</sup> i.e. students that have been at the university two years or longer

Although some questions were qualitative in nature, the data were quantitatively coded to facilitate analysis. For example, students were asked to identify how the pandemic has affected their likelihood of using certain modes, and responses of “significantly less likely to use”, “neutral”, and “significantly more likely to use” were given numerical representations of 1, 3, and 5, respectively. This allowed the authors to numericize categorical variables to create and interpret summary statistics. The authors also grouped open-ended suggestions into the themes that the recommendations addressed, such as pedestrian infrastructure, bus options, and parking, to determine what aspects of transportation services student respondents primarily suggested changing.

#### **IV. Interview Results**

Several themes emerged from these interviews. Many schools stressed the importance of focusing on the safety and convenience of alternative transportation modes on campus. Administrators and decisionmakers on university campuses are often more likely to be swayed by arguments surrounding these ideas rather than sustainability. The director of transportation services at Johns Hopkins mentioned that the university subscribes to the belief that one pedestrian safety incident is too many. With this in mind, Johns Hopkins has developed a robust alternative transportation system, highlighted by the Blue Jay Shuttle service, which is a point-to-point, on-demand ride hailing service run by the university. This service provides safety as well as convenience of mobility to the student body, and it lessens a dependence on private automobiles. Unfortunately, such a service can be costly for universities to administer.

The cost of services is another subject that often arose in these conversations. Creating sustainable transportation on campuses requires hefty investments. Another example of costly programming comes from incentive-based commuting systems offered by schools such as Oregon Health & Science University (OHSU) and Vanderbilt University. OHSU offers a \$1.50 incentive for each inbound trip to the university via walking or biking, and although such a program has helped the school increase its alternative mode share (e.g., 15% bicycle mode share or double the average of the rest of Portland), it also costs roughly \$543,000 annually. Vanderbilt plans to implement a \$0.50 incentive for sustainable commute modes, and according to the school’s executive director of mobility such incentives are necessary to shift mode share away from single-occupancy vehicles. Numerous interviewees indicated that this is especially true in the South,

where political culture generally favors commuting by personal vehicle rather than more sustainable modes.

Both OHSU and Vanderbilt have also adopted or plan to adopt an approach that would ask commuters to pay daily for parking rather than selling monthly or annual permits. This approach has the potential to incentivize commuters to take alternative modes on days when it is convenient, rather than feeling pressure to drive to validate their monthly or annual parking pass investment. Such a technique may diminish parking revenue in the short run, but this transportation demand management strategy allows universities to save money in the long run by avoiding the costs of building new parking lots and garages as campuses continue to grow.

Apart from direct investments and expenditures, universities can improve their effectiveness in implementing alternative modes through the management of their parking and transportation budgets. Keeping parking and transportation budgets separate allows transportation departments to create alternative modes without administrative concern about crippling the department's source of funding. Where the transportation department is housed can also be meaningful. Many transportation departments are part of auxiliary services at a university. At North Carolina Central University, however, the transportation department is part of the office of student affairs. According to the school's director of transportation & parking services, this allows the department to be more intertwined in meetings and events on campus. They are very active at new student orientation, attend all student affairs meetings, and can more easily engage leadership at the university because of this administrative structure. This would be a change that a university can make at presumably low cost that would allow transportation logistics to be more apparent in university decision making and events.

Other schools have embraced strategies that consolidate commuter transportation information, services, and incentives. This often takes the form of a single transportation mobile app that can help track commuter benefits, build carpool groupings, give bus location data, and spread information about new services. OHSU has consolidated its resources in its Luum platform.<sup>26</sup> They have had success conveying and spreading information in this application, as 60% of university affiliates have accessed the platform, and 30% use Luum regularly. Consolidating information and resources in this way has the potential to expand awareness and engagement with alternative transportation at little cost to a university.

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<sup>26</sup> See <https://go.luum.com/> for more information on this service.

Ultimately, most schools acknowledged that they could improve communication of alternative transportation services to students and employees on campus. This is especially true for colleges in the South and schools that do not hold direct control over their roadways. Several schools, however, have overcome infrastructure and cultural barriers to creatively expand awareness and use of alternative transportation modes on campus. The University of Rochester focuses on educational outreach, such as bicycle courses that teach entry-level skills, how to fix a flat tire, and how to ride your bike in various weather conditions.<sup>27</sup> Some of these classes have seen a fourfold increase in attendance since they were first offered. The university also sees these classes as a way for those affiliated with the school to feel safe, informed, and comfortable when biking to and around campus (see Figure A1 in the appendix for images showing alternative transportation support and use at the University of Rochester). The University of Washington (UW) also focuses on dissemination of information, as it has a quarterly newsletter specifically for all holders of its transit passes, maintains a strong social media presence, and targets specific groups of university affiliates with focused e-mail campaigns. UW's transportation services department also maintains a strong relationship with the sustainability office at the university, and they collaborate on cross-departmental informational campaigns and events.

Other schools have leveraged new-student orientations to spread information and awareness about alternative modes. Colorado State University has a series of short videos that it has developed that aim to inform future cohorts about alternative transportation options and safety. The school has these videos on its Canvas page along with links to more detailed information, and it plans to make viewing mandatory for all students moving forward. These videos are professionally produced but are not school-specific and could be another low-cost option for adoption for other schools hoping to spread information about alternative transportation without extensive investment. Colorado State's investment into alternative modes is evident, as seen in the campus' extensive bicycle and pedestrian infrastructure (see Figures A2 and A3 in the appendix for images displaying this infrastructure and culture supporting bicycle use on campus).

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<sup>27</sup> See [https://events.rochester.edu/event/bicycle\\_winter\\_class\\_5894#.YFvSBq9KhPY](https://events.rochester.edu/event/bicycle_winter_class_5894#.YFvSBq9KhPY) for an example of one of the University of Rochester's winter bicycle classes.

## V. Survey Results

The following section reveals the results from the survey of graduate students. The research considers results from 398 survey respondents from all of Duke's domestic graduate schools. Although the sample is not fully representative of Duke's graduate student body, the authors nonetheless believe that the results can be used to derive insights on this population.

### 1. Demographics

Of all respondents, 28% attended the Nicholas School of the Environment, making this the most represented school in the survey (see Figure 1 for a full breakdown of respondents by school at Duke). Most students identified as female, and most respondents identified as white. Table 4 contains other demographic information.

Figure 2 shows a heat map of the closest major intersection to student residences. As one can see, many respondents live in the neighborhoods close to Erwin Road and LaSalle Street, the Ninth Street area, and in the western parts of downtown Durham. However, student residences expanded into Chapel Hill, Raleigh, and other surrounding municipalities.

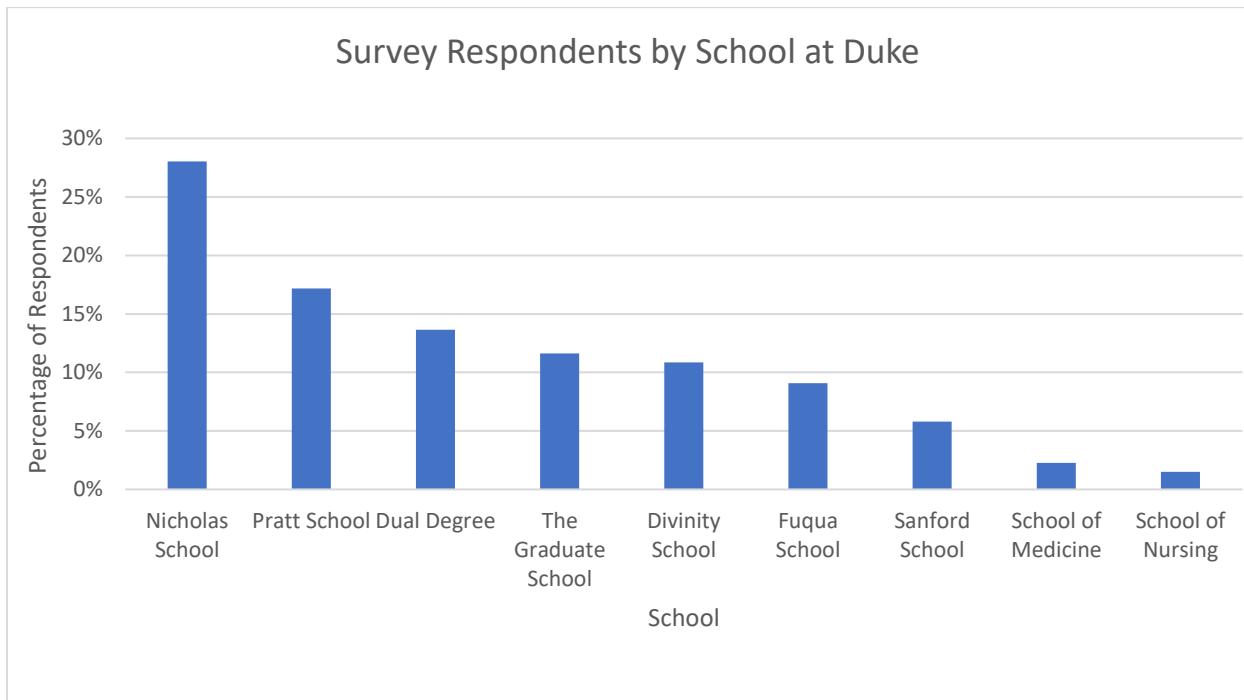


Figure 1. Survey Respondents by School at Duke University

Table 4. Demographic Information of Survey Respondents

Demographic Category		Total Number of Respondents	Percent of Respondents
<i>Gender</i>	Female	227	57%
	Male	146	37%
	Non-binary	3	1%
<i>Race</i>	White	246	62%
	Asian	71	18%
	Latinx	16	4%
	Black or African American	13	3%
	Multiple Races	21	5%
<i>Progress in Academic Program</i>	First Year	146	37%
	Second Year or Greater	250	63%
<b>Mean of Responses</b>			
<i>Average Age (years)</i>		26.54	
<i>Average Distance from Campus (miles)</i>		3.16	
<i>*Not all percentages sum to 100% because of fields left blank by some respondents</i>			

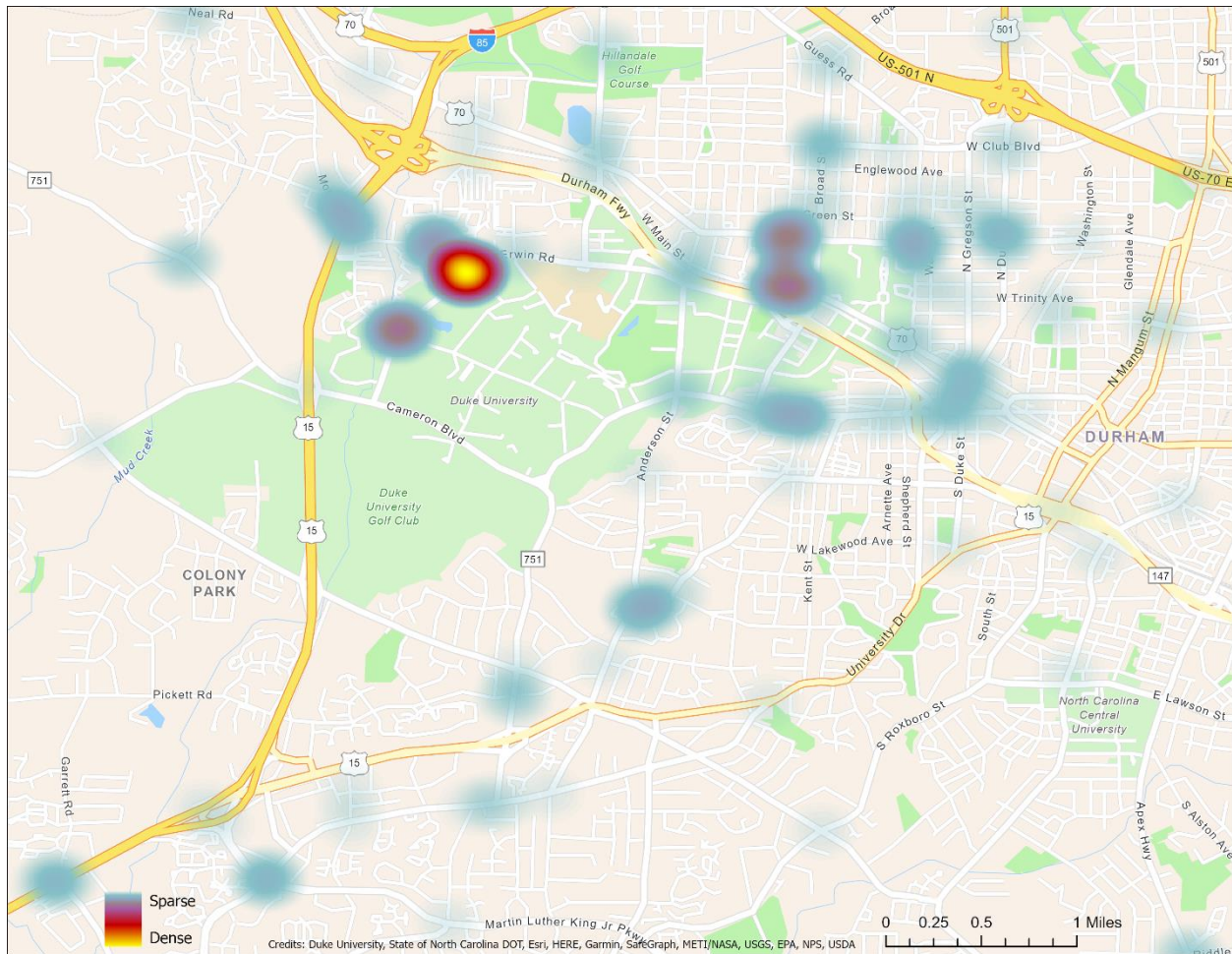


Figure 2. Heat Map Showing the Closest Major Intersections to Respondents' Residences (Zoomed-in on Durham, NC)<sup>28</sup>

## 2. Knowledge

Overall knowledge and use of transportation services were quite low, as predicted. Greater than 60% of respondents had never heard of or used six of the nine transportation services included in the survey. Two exceptions to this were comparatively high knowledge of bike racks and Duke-issued transit GoPasses. Respondents indicated little knowledge and use of most of the other services outlined in the survey, as seen in Figure 3.

<sup>28</sup> Map Layer Credits: Duke University, State of North Carolina DOT, ESRI, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA

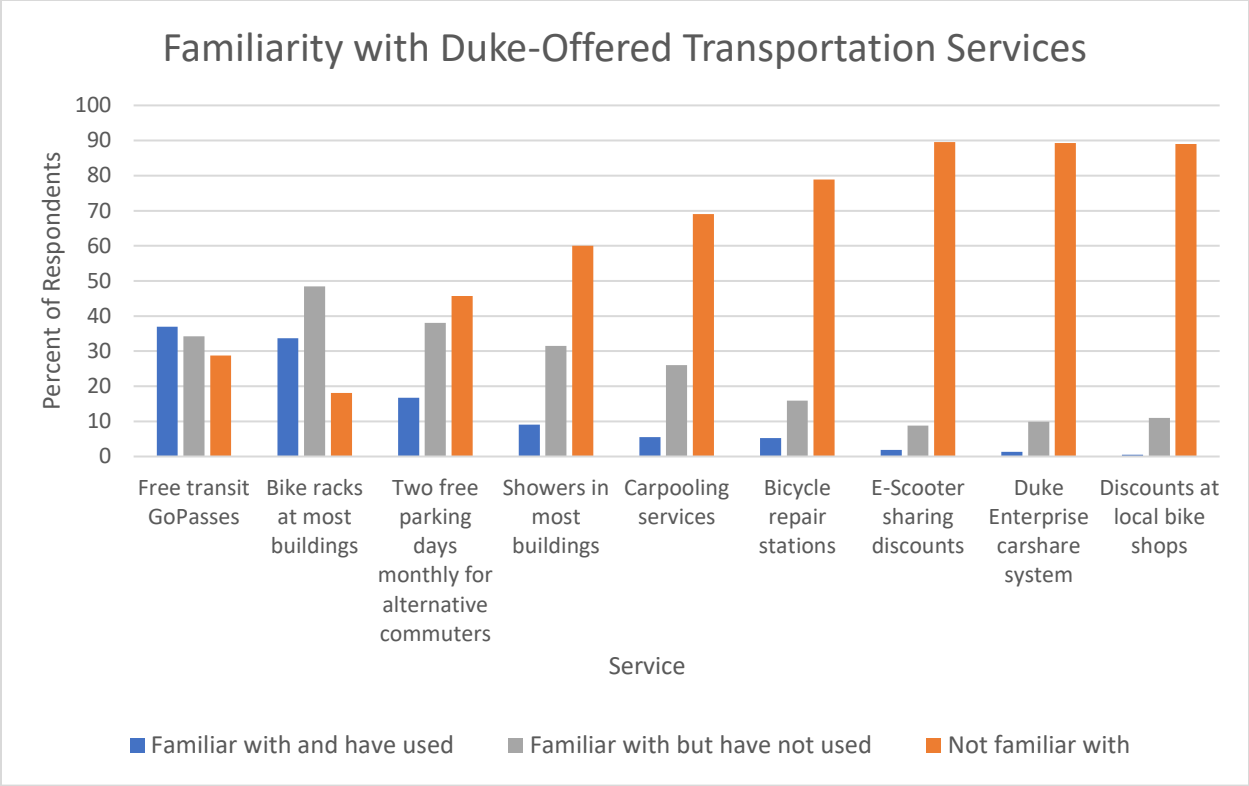


Figure 3. Survey Respondent Familiarity with Duke University’s Transportation Services

3. *Barriers*

In general, safety, time, and convenience factors were the primary barriers to alternative transportation use, as seen in Figure 4. Reliability concerns were apparent for bus use but were generally not as prominent for other modes. Hygiene and physical limitations were not listed as significant concerns, although they were relevant for walking and biking. See Figure A4 in the appendix for a full description of barriers to alternative transportation use by graduate student commuters.

Students were asked if they agreed with the statement that they were generally comfortable using various forms of alternative transportation to commute to campus. The average of responses indicated that students were largely comfortable taking the bus and carpooling. Respondents also indicated mean comfort levels above neutral for walking and biking, although comfort level was comparatively lower for these pedestrian modes compared to taking the bus and carpooling. The only mode which had mean responses below neutral was E-scooter, indicating comparatively low average comfort levels. See Figure 5 for a full description of comfort levels.

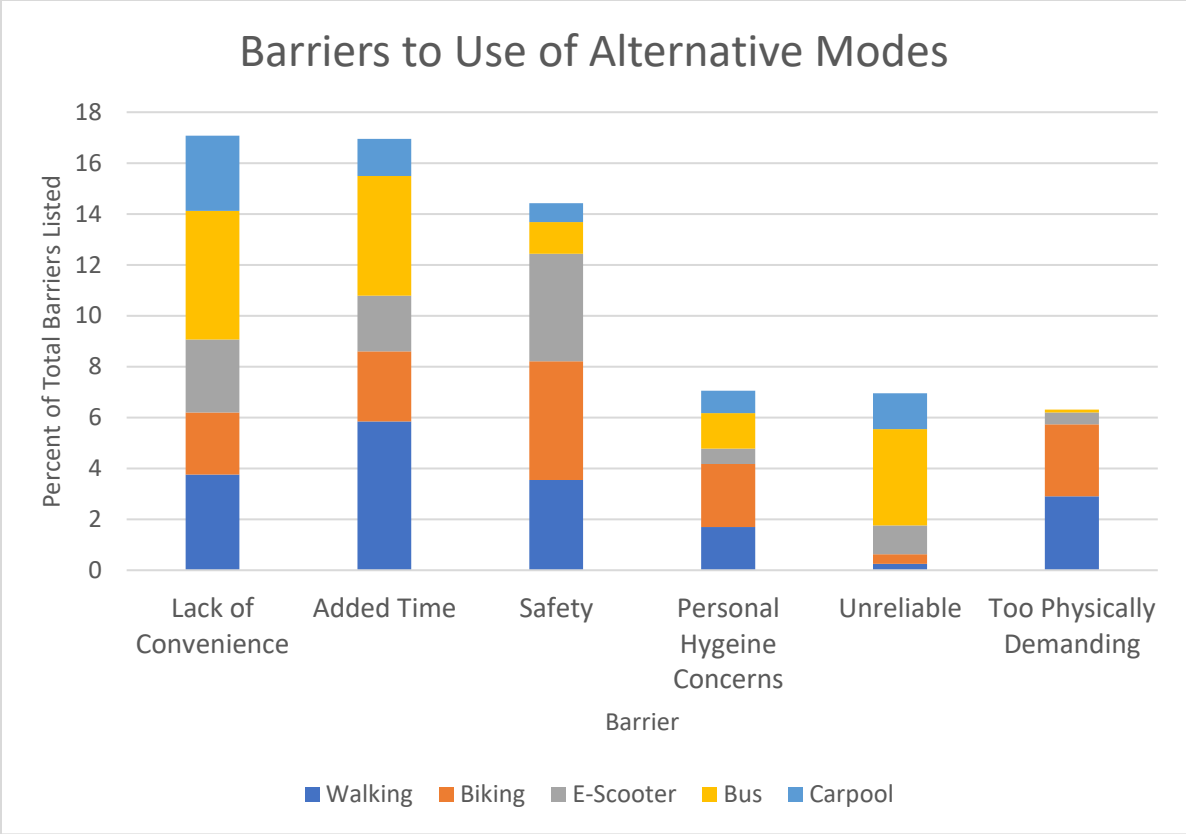


Figure 4. Barriers to Respondent Use of Alternative Modes to Commute to Duke University’s Campus<sup>29</sup>

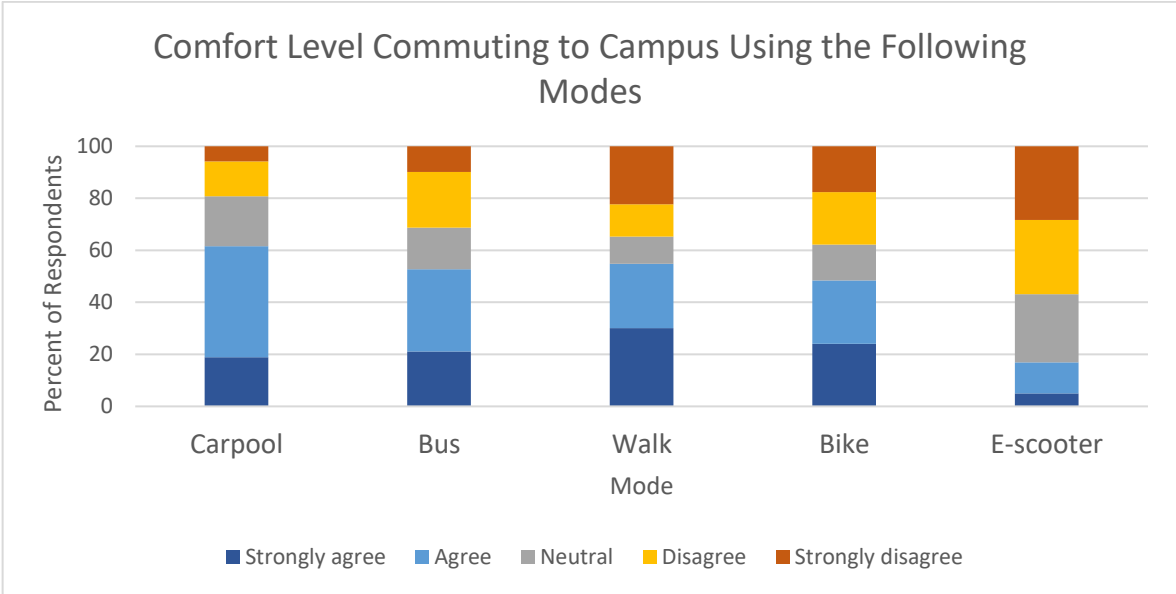


Figure 5. Respondent Comfort Level Commuting to Campus Using Alternative Modes

<sup>29</sup> Because this graph does not represent all the barriers listed in the survey, it does not add to 100%.

#### 4. Conveying Information

The survey asked respondents to identify how they learned about Duke’s transportation services. The results suggest that students primarily received information on these services via Duke’s transportation website and word of mouth from other students. Respondents were also asked to identify what would be their preferred means of receiving information on transportation services. Responses to this question suggest that respondents would like to receive more information distributed via student-wide e-mails, as indicated in Figure 6. This figure also suggests that some respondents desire greater information spread via social media.

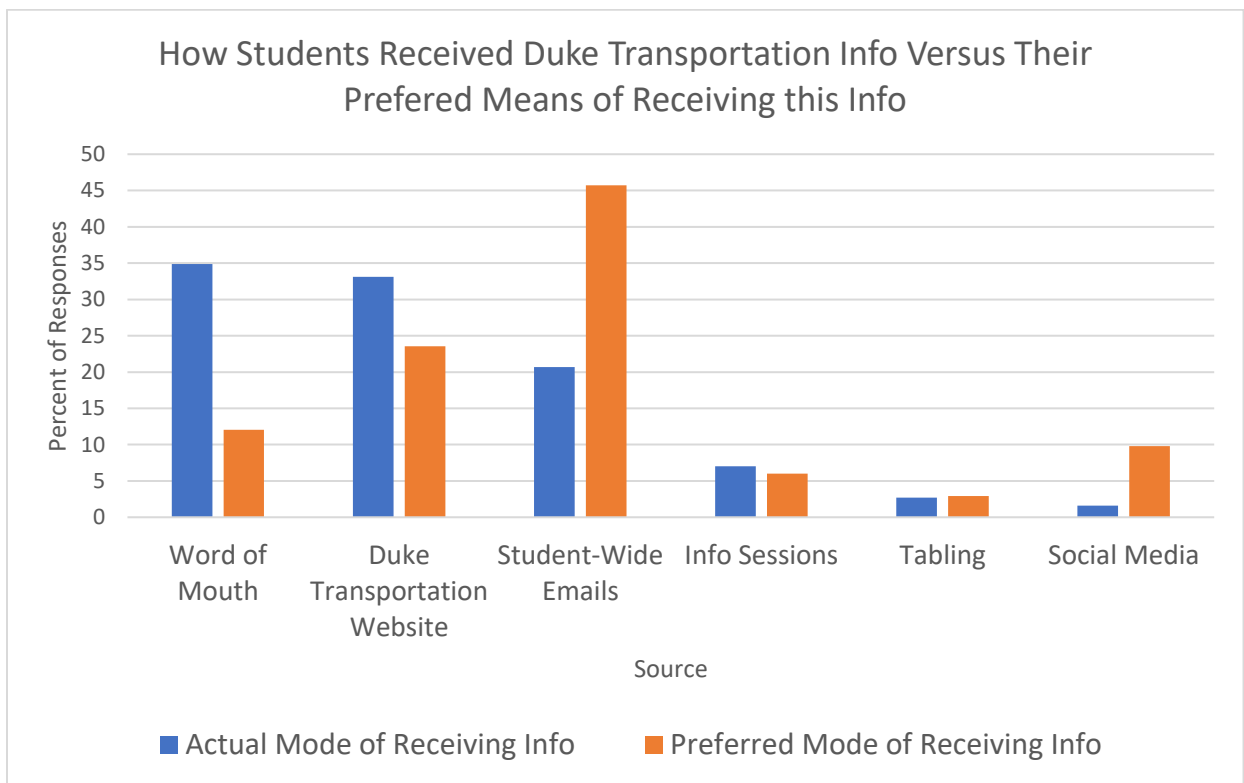


Figure 6. Survey Respondent Methods of Learning About Duke University’s Transportation Services Versus Preferred Means of Receiving Information

#### 5. Commuting Patterns and Ownership

The survey asked how many times respondents used various modes to commute to campus each week. Respondents commuted to campus most frequently using single-occupancy vehicles, followed by walking, taking the bus, and biking. See Figure 7 for a full description of commuting patterns.

Many more respondents owned cars in Durham compared to bicycles, mopeds, and E-scooters. Although more than half of respondents indicated access to transit GoPasses, the number of students with access to carsharing accounts and E-scooter sharing accounts was comparatively low. See Figure 8 for a full description of ownership of transportation devices and access to transportation services.

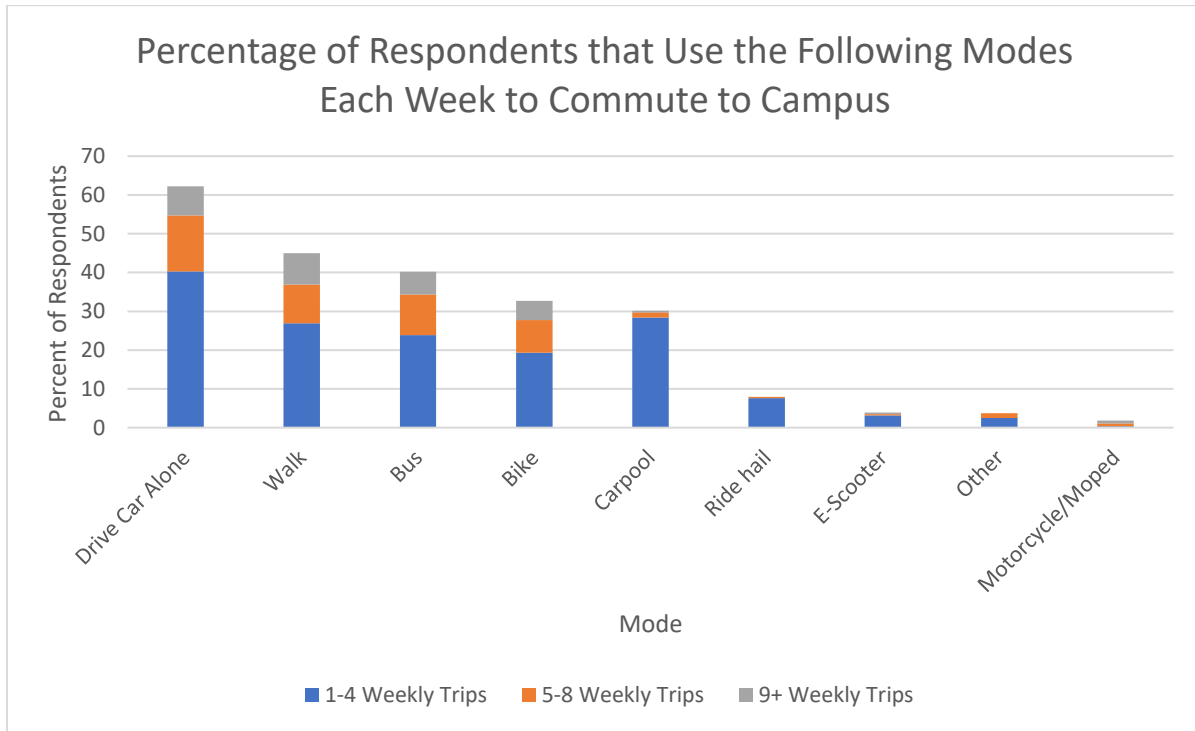


Figure 7. Survey Respondent Commuting Patterns

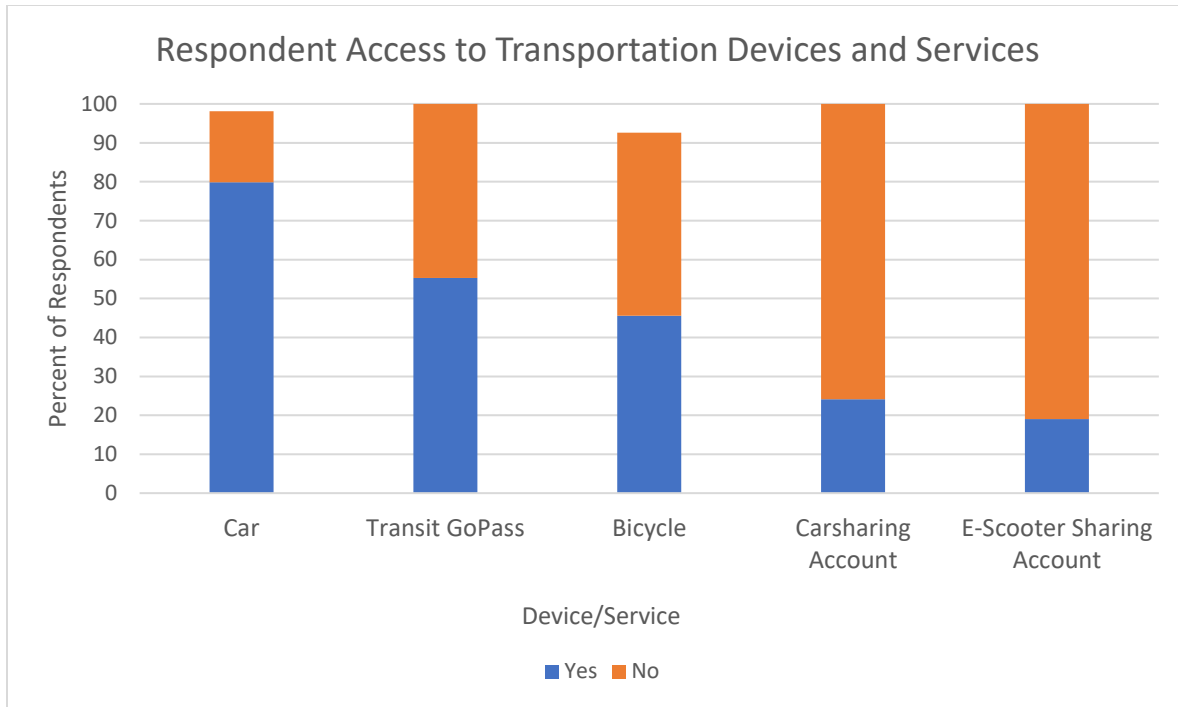


Figure 8. Survey Respondent Ownership of Transportation Devices and Access to Transportation Services<sup>30</sup>

## 6. COVID-19 Impacts

Students were asked how the COVID-19 pandemic has impacted their likelihood to use various modes. Single-occupancy vehicle was the mode that constituted the largest increase in comfort levels during the pandemic, followed by walking and biking. Student responses also indicated that they were less likely to take the bus, use ride hail services, and carpool, and were slightly less likely to use E-scooters during the times of COVID-19. See Figure 9 for a full description of the impact of COVID-19 on likelihood to use different modes.

<sup>30</sup> Some responses of “other” were given by students who own cars or bicycles but do not have them at their current residences. Accordingly, some of these percentages do not add to 100%.

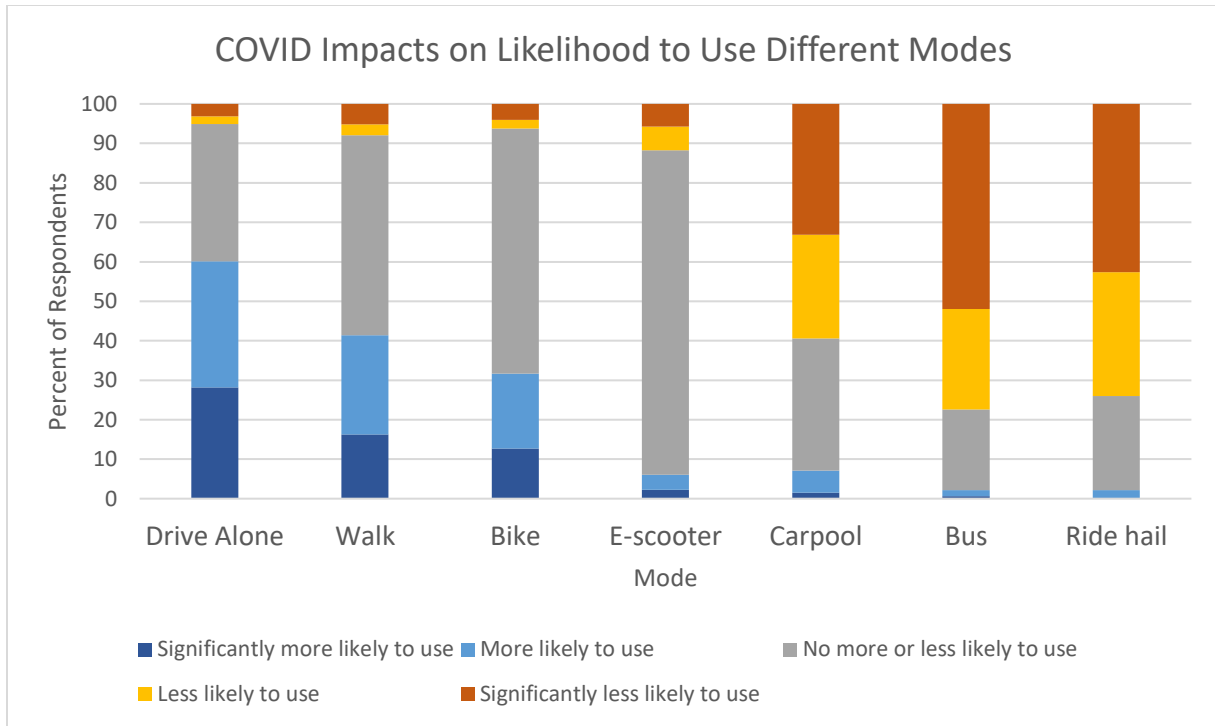


Figure 9. COVID-19 Impacts on Respondent Likelihood to Use Different Modes of Transportation

### 7. Response Variation by Progress in Academic Program

Responses also varied between first year students and students that have been at the university for two or more years.<sup>31</sup> First year students were significantly less likely to have transit GoPass accounts ( $p < .001$ ,  $t = 11.12$ ,  $df = 298.59$ ) and E-scooter sharing accounts ( $p = .040$ ,  $t = 2.06$ ,  $df = 326.65$ ) compared to non-first year students.<sup>32</sup> First year student responses also showed lower mean values for familiarity with all nine services mentioned in the survey. Respondents from this group were more likely to say that they were comfortable walking, biking, and taking E-scooters to campus (i.e. open-air modes) but were less comfortable taking the bus and carpooling compared to non-first year students. First year students are also commuting to campus less overall compared to how non-first year students commuted in the past, and on average live further away from campus than non-first year students. See Table 5 for a complete comparison of these two groups.

<sup>31</sup> It is hypothesized that first year students may be less likely to use and seek knowledge of certain alternative modes (i.e. bus, carpool) compared to non-first year students in the past due to the COVID-19 pandemic.

<sup>32</sup> The authors performed independent 2-group Welch's t-tests with a significance threshold of 0.05 for all significance testing.

Table 5. Comparison of First Year and Non-First Year Student Responses to Different Survey Questions

Survey Question		Mean of Responses		Standard Deviation	
		First Years	Second+ Years	First Years	Second+ Years
Do you have access to the following? <i>1 = no</i> <i>2 = yes</i>	Transit GoPass	1.24	1.75	0.43	0.44
	E-Scooter Sharing Account	1.14	1.22	0.35	0.42
	Carsharing Account	1.25	1.24	0.43	0.43
Are you familiar with the following? <i>1 = not familiar with</i> <i>2 = familiar with but have not used</i> <i>3 = familiar with and have used</i>	Bike Repair Stations	1.14	1.34	0.39	0.61
	Discounts at Local Bike Shops	1.09	1.14	0.28	0.37
	Showers Facilities	1.18	1.69	0.40	0.71
	Bike Racks	1.99	2.26	0.75	0.66
	Carpool Services	1.16	1.49	0.43	0.63
	Free Transit GoPasses	1.50	2.45	0.62	0.69
	E-Scooter Sharing Discounts	1.07	1.16	0.29	0.43
	Enterprise Carshare	1.05	1.17	0.22	0.43
	Free Daily Parking Passes for Alternative Commuters	1.56	1.80	0.67	0.76
Are you comfortable using the following modes to commute to campus? <i>1 = strongly disagree</i> <i>3 = neutral</i> <i>5 = strongly agree</i>	Walk	3.47	3.18	1.48	1.58
	Bike	3.37	3.07	1.43	1.44
	E-Scooter	2.56	2.25	1.17	1.13
	Bus	3.12	3.47	1.34	1.25
	Carpool	3.51	3.58	1.20	1.07
How often do you commute to campus using the following modes? <i>Higher mean values correspond to more total trips using mode</i>	Walk	1.85	2.24	1.25	1.74
	Bike	1.60	1.88	1.09	1.54
	E-Scooter	1.00	1.11	0.00	0.51
	Motorcycle/Moped	1.00	1.10	0.00	0.62
	Drive Car Alone	2.12	2.54	1.25	0.66
	Carpool	1.36	1.44	0.59	0.80
	Bus	1.51	2.18	1.04	1.59
	Ride Hail	1.09	1.11	0.47	0.37
Other	1.14	1.06	0.63	0.37	
Distance of Residence to Campus	<i>(in miles)</i>	3.31	3.07	4.96	3.53

## 8. Response Variation by Gender

Comfort levels of using alternative modes across gender can be a strong indicator of alternative transportation success. In particular, the presence of robust pedestrian infrastructure is generally correlated with higher comfort levels of female bikers.<sup>33</sup> The survey data suggest that female respondents were significantly less comfortable than male respondents biking ( $p = .002$ ,  $t = 3.15$ ,  $df = 248.11$ ) and E-scootering ( $p = .001$ ,  $t = 3.48$ ,  $df = 189.84$ ) to campus. See Figure 10, which demonstrates these findings and comfort levels using other alternative modes. Male respondents also commuted via bicycle more frequently than female respondents, while female respondents were more likely to drive alone, carpool, or use ride hailing services (Table 6).<sup>34</sup>

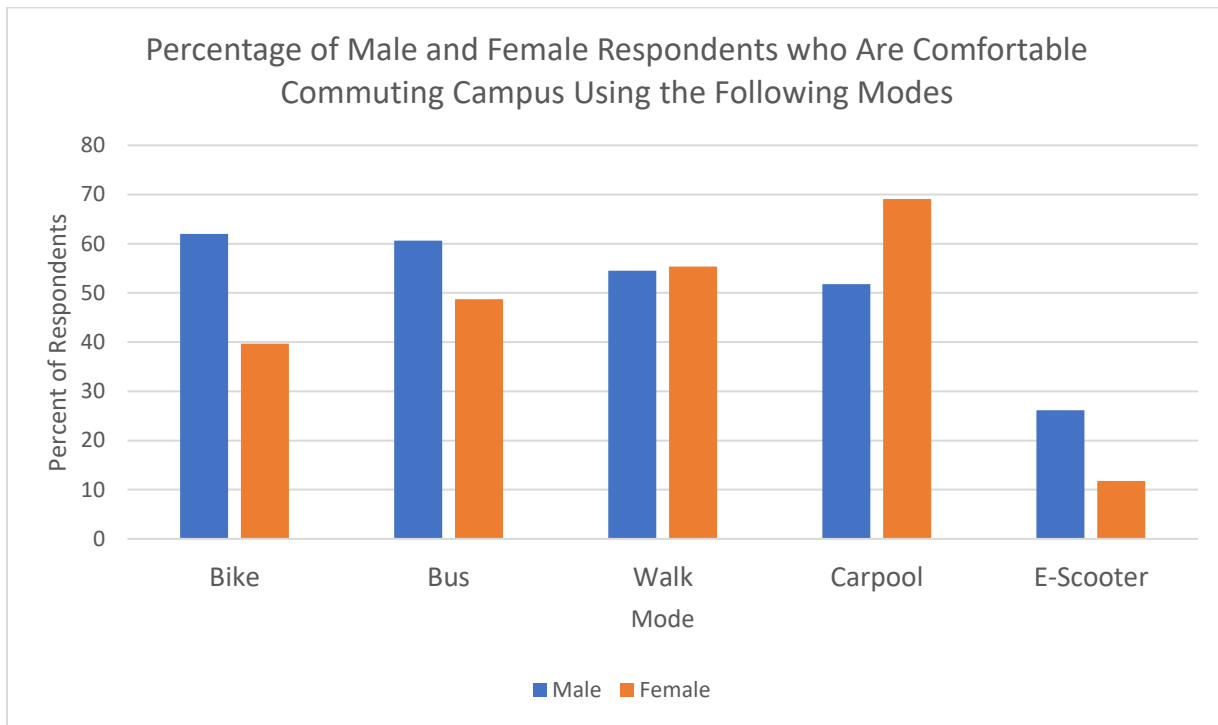


Figure 10. Comfort Level with Biking to Campus Among Male and Female Respondents

<sup>33</sup> Jaffe, “Explanation for the Gender Gap.”

<sup>34</sup> Although some survey respondents identified as non-binary or preferred not to share their gender, the sample size of these responses was very low. Because of this, these responses are not included in this section so as not to misrepresent a gender identity based on insufficient data.

Table 6. Comparison of Male and Female Responses to Different Survey Questions

Survey Question		Mean of Responses		Standard Deviation	
		Male	Female	Male	Female
Are you comfortable using the following modes to commute to campus? <i>1 = strongly disagree</i> <i>3 = neutral</i> <i>5 = strongly agree</i>	Walk	3.34	3.24	1.53	1.57
	Bike	3.49	2.96	1.47	1.40
	E-Scooter	2.69	2.18	1.28	1.04
	Bus	3.49	3.24	1.34	1.26
	Carpool	3.37	3.69	1.20	1.05
How often do you use the following modes to commute to campus? <i>Higher mean values correspond to more total trips using mode</i>	Walk	2.03	2.11	1.58	1.56
	Bike	1.97	1.63	1.47	1.29
	E-Scooter	1.12	1.04	0.45	0.39
	Motorcycle/Moped	1.12	1.02	0.74	0.24
	Drive Car Alone	2.27	2.45	1.57	1.50
	Carpool	1.37	1.45	0.63	0.79
	Bus	1.95	1.95	1.49	1.45
	Ride Hail	1.07	1.13	0.42	0.40
Other	1.07	1.10	0.36	0.55	

#### 9. Response Variation by Graduate School

There were variations in preferences among students from different graduate schools at Duke as well. Figure 11 shows student propensity to commute to campus via bicycle by graduate school. As one can note, respondents from the Nicholas School of the Environment generally biked to campus more often on average than respondents from other schools. More than 40% of respondents from the Nicholas School indicated that they bike to campus at least once each week, while less than 15% of students from the Fuqua School commuted via bicycle at least once each week.

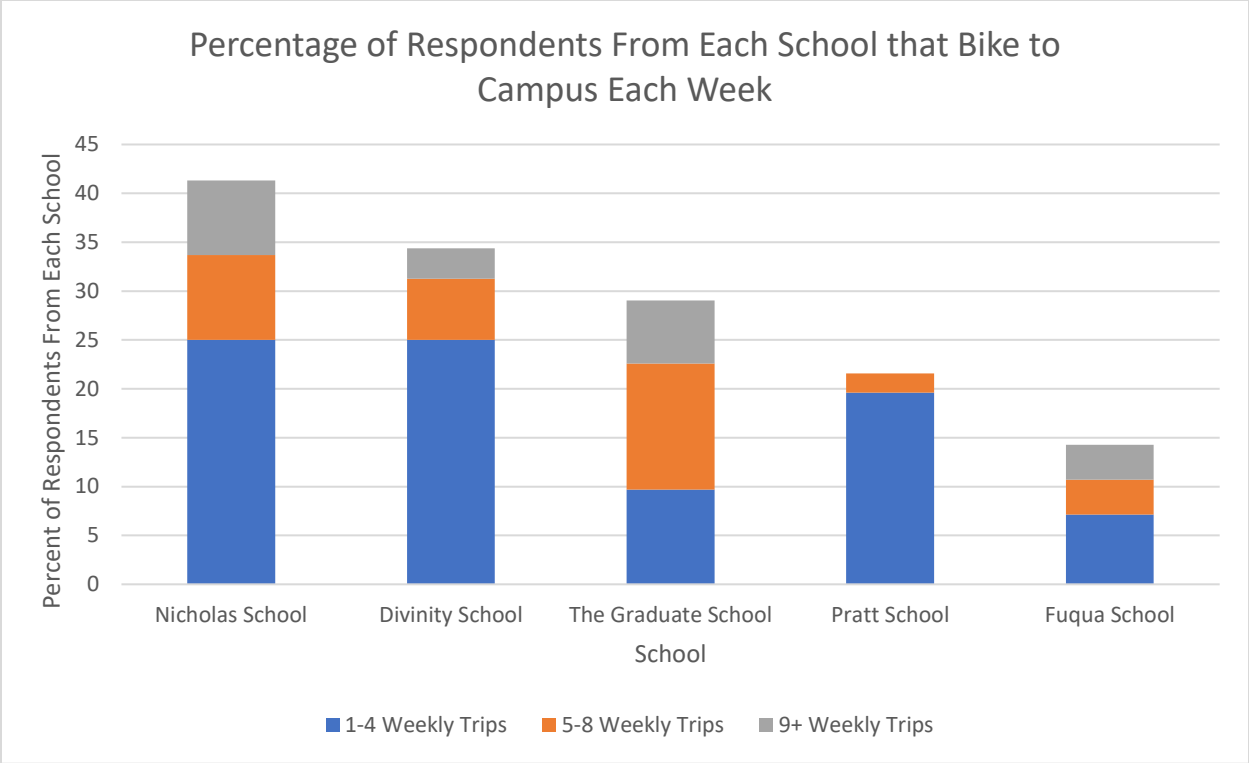


Figure 11. Bicycle Commuting Trends by School Among Respondents

10. Open-Ended Suggestions

All respondents were asked open-ended questions about what additional services they would like to see Duke offer moving forward. The responses were categorized into various themes, as seen in the bar chart in Figure 12. The word cloud in Figure A5 in the appendix shows the most common words and phrases that these suggestions contained. In general, a stronger focus on bus accessibility and better pedestrian infrastructure were commonly cited suggestions by respondents.

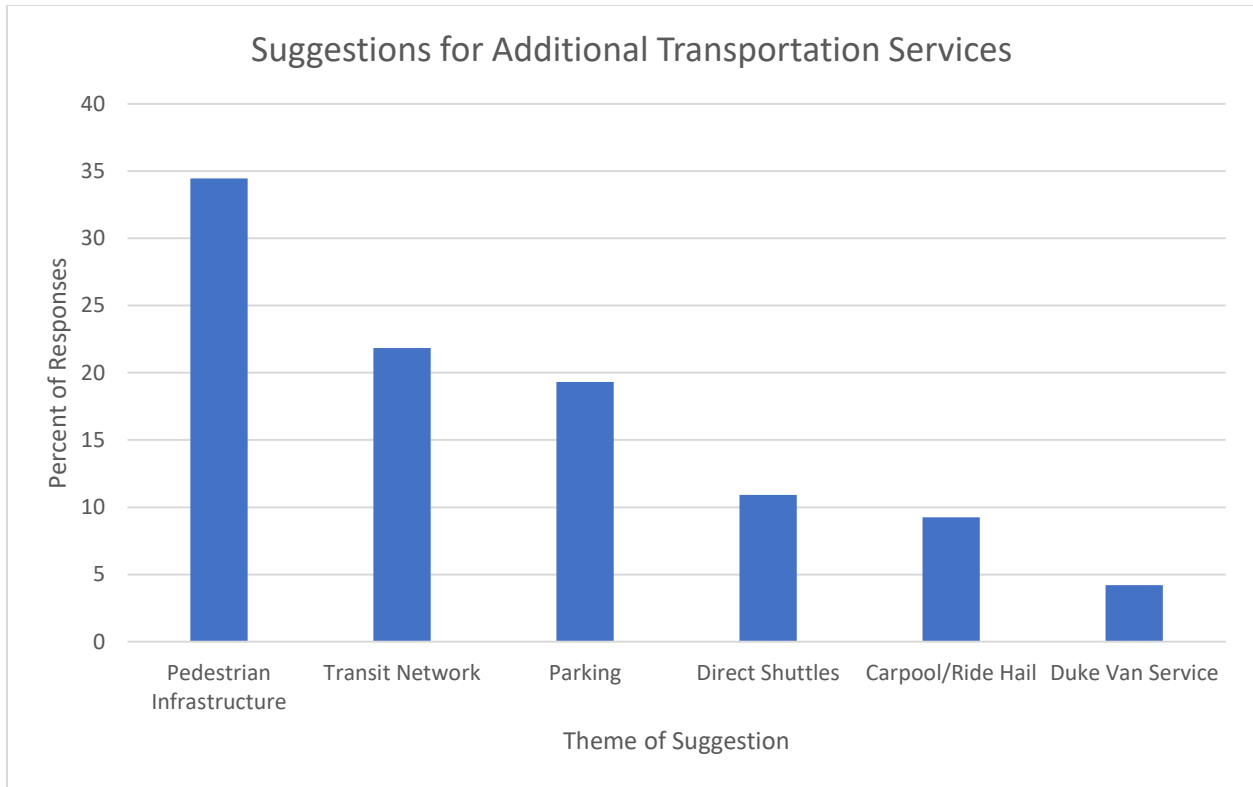


Figure 12. Themes of Open-Ended Suggestions for Transportation Services Among Respondents

## VI. Discussion

### 1. Findings

The literature review and interviews conducted by the researchers in this study allowed them to formulate a targeted survey that gleaned insights into graduate student use and knowledge of alternative transportation modes and services at Duke. Many of the survey results align with what was uncovered in the literature review and interviews, such as safety, time, and convenience concerns serving as primary barriers to alternative transportation use. Other notable results of the survey findings are discussed in further detail below. These results will be used to construct informational materials that will better inform students at Duke of their transportation options, which is further discussed below and in the following section of this report.

### 2. Discussion of Survey Results

The study's three primary findings were that knowledge of transportation services was very low; convenience, time, and safety concerns were the primary barriers to alternative transportation use; and graduate students desire more information distributed via widespread e-mails. Other

notable results include the gap between male and female comfort levels for pedestrian activity, the propensity for students to commute to campus via single-occupancy vehicle, and the impact of the COVID-19 pandemic on comfort using certain modes. Informational materials will be constructed with these results in mind.

i. Knowledge

The generally low knowledge of Duke's transportation services validated the need for this study. Aside from bicycle racks and free transit GoPasses, students were comparatively unfamiliar with and indicated low usage rates of other transportation services mentioned in the survey. The existence of this knowledge gap between transportation services and student awareness and use of those resources establishes the need for a targeted informational campaign.<sup>35</sup>

ii. Barriers

A perceived lack of safety and convenience and the lengthening of commute times served as primary barriers to alternative transportation use. Informational materials will work to address these student barriers to alternative transportation use. Time and convenience (and safety to a degree) concerns can be addressed indirectly by encouraging students to live closer to campus or in certain neighborhoods that have bus access or strong pedestrian infrastructure. Although higher comfort levels cannot be fully established without real changes to the built environment, some safety reservations can be addressed through greater awareness of how to commute safely as a pedestrian and knowledge of resources that support these modes.

With these concerns in mind, the researchers will construct informational materials that will target students soon after enrollment to discuss housing and transportation options. Preparatory materials such as the Nicholas School's ePack e-mails will be an initial channel through which to distribute this information.<sup>36</sup> Additionally, these materials will incorporate the added health benefits of active modes of transportation, which the literature review indicated is a persuasive

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<sup>35</sup> Researchers also recognize that this study was conducted during the midst of the COVID pandemic, and this could have impacted student knowledge of services due to less on-campus engagement. This research should be repeated in future years to validate these results.

<sup>36</sup> The Nicholas School's ePacks are a series of informational orientation e-mails with links to resources that are helpful to students who have recently enrolled in the school.

piece of information. An understanding of this benefit could work to counteract perceived safety barriers in the commuter decision making process.

### iii. Conveying Information

The indication that student respondents preferred to receive more information via student-wide e-mails helped to narrow the focus of the proposed informational campaign. Although the Nicholas School's ePacks will serve as an initial mode through which to distribute the materials, this result indicates that this research can be disseminated effectively through future e-mail campaigns by Sustainable Duke, Duke's Office of Parking & Transportation, and various schools at Duke. This campaign could also be distributed through social media, which responses indicate is a mode which transportation entities at Duke could further employ when advertising.

### iv. Impact of COVID-19

Less familiarity with and access to many of Duke's alternative transportation services and resources among first year students suggests that the pandemic is making students less likely to use and seek out alternative modes. This is a trend that should be examined moving forward with new classes of Duke graduate students, as it could be a recurring theme even in post-pandemic times.

It was encouraging to see the general access to, comfort with, and use of Durham's and Duke's bus systems among students. However, the possibility of transit playing less of a role in students' lives moving forward should be taken seriously, largely due to the observed results of lower use, comfort level toward, and knowledge of transit services among first year students compared to non-first year students. A decrease in ridership and revenue moving forward could work as a negative feedback mechanism to bus services offered both by Duke and by the GoDurham and GoTriangle transit authorities. This is a particularly salient topic considering improving the bus network was the second most cited suggestion of respondents in the open-ended survey question. Accordingly, informational materials will contain information on the merits of bus systems and how they can be safe and sustainable moving forward.

As stated in the results, commuting in general among first year students is lower compared to how non-first year students commuted in the past. This is not a surprise, considering how much of Duke's coursework has been moved online this year. If additional opportunities for online classes

are offered moving forward in post-pandemic times, this could increase telecommuting and reduce total commuting needs of graduate students. However, if students are only commuting to campus on occasion, this could incentivize them to live further from campus and drive to Duke when necessary. Evidence for this potential trend exists in the fact that first year survey respondents live roughly one-quarter mile further away from campus on average compared to non-first year respondents. This underscores the need for informational materials to discuss the merits of living close to Duke's campus. Higher comfort level with open-air modes among first year students, and greater likelihood to use these modes among all students during the times of COVID-19 also create the opportunity to advocate for walking, biking, and E-scooter moving forward from a public health perspective.

#### v. Student Commuting Patterns

One of the primary imperatives of this project was to get students out of single-occupancy vehicles and into other modes of transportation. The propensity for graduate students to drive alone to campus was noted in the results, as more than 60% of respondents indicated that they drive alone to campus at least once each week, higher than any other mode. Car ownership was also much more frequent than ownership of other transportation devices or access to transportation services. This result validated the need for the study and for further exploration into means of expanding sustainable mode share.

### 3. *Potential Limitations*

This analysis has some limitations. The discussion of results including first and non-first year students is missing the variable of time spent on campus. Greater time spent on and around campus by non-first year students likely led to greater knowledge of available transportation services. Although it is likely that the COVID-19 pandemic has also diminished use and knowledge of certain alternative modes by first year students, it is impossible to separate this from the effect of additional experience in the Triangle area. This survey should be conducted in additional years to fully understand whether the pandemic or added time spent near campus account for the varying use and knowledge of alternative transportation modes and services.

As mentioned, first year students were also asked to answer all survey questions relating to how they currently commute to campus, but non-first year students were asked to answer the

questions regarding how they commuted to campus before the pandemic began. However, it seems likely that not all non-first years read or understood the prompt given to them. For example, some non-first year students responded that they generally did not commute to campus on a given week last year, which is very unlikely considering the majority of courses and student activities were offered in-person before the pandemic. This could bias the data and the connections between first year and non-first year students, which is partially attributed to the impact of the pandemic. However, it is believed that this potential confusion was minor, and the responses can still be used to form valuable insights.

Due to the authors' connections with the Nicholas School, respondents were also disproportionately students from this school. Nicholas School students, who are more environmentally focused, have the potential to skew the results, such as likelihood to use modes like biking to commute to campus (as seen in Figure 11). This should be kept in mind when analyzing these results in their entirety. Moving forward, when corresponding with different schools, results will be subdivided on a school-by-school basis. Results can be tailored to the needs and trends exhibited by each school in this way.

## **VII. Recommendations and Plan for Informational Materials**

Both the literature review and survey findings in this study validated the need for and utility of the strategies outlined by McKenzie-Mohr. The created informational materials will utilize the compiled research to target the pieces of information that are most likely to change student behavior. A short informative write-up will be created and distributed throughout the Duke student community to inform individuals of transportation options and resources, and it will address the concerns that many respondents have voiced in this analysis. Included with this write-up will be bus-friendly and bicycle-friendly housing maps with paired data of respondent residence locations and commuting habits.

It will be imperative that these maps and other corresponding written materials relating to Duke's living options are viewed before students arrive on campus. As much of students' commuting decisions are decided when they choose their housing, providing them with this information before a decision is made will be crucial. Accordingly, these materials will be distributed in the Nicholas School's ePack that is focused on student housing options, which is sent out in May. If these materials are successfully piloted in the Nicholas School's housing ePack,

it is hoped that Sustainable Duke and other actors at the university can find other channels through which to distribute them. One option would be to convert these materials into e-mail blasts and targeted campaigns, which student responses indicate are a preferred means of information dissemination.

These materials can serve as a prototype for a comprehensive online orientation module for incoming students. If materials are successfully deployed among the Nicholas School's incoming class, the authors of this study propose that viewing be required for all new Duke graduate students (and potentially undergraduate students) in the coming years. A similar approach can be used for the onboarding process for new staff and faculty hires if it proves to be successful.

Other universities and colleges have proven that informational materials can be a useful means of disseminating information on campus without extensive investment. This has allowed biking to take hold at the University of Rochester despite its cold climate, as well as a commitment to cycling at Colorado State University partially driven by a series of low-cost but professionally produced videos. More collaboration and sharing of ideas between Duke and schools such as these could benefit the university's efforts to increase sustainable mode share moving forward.

## **VIII. Conclusion**

Through the completion of a literature review and interviews with other university officials, the authors of this study sought to better understand the barriers to alternative transportation use on college campuses. They also hoped to better understand elements of environmental psychology to overcome barriers to environmentally-friendly behavior. They used the framework of a community-based social marketing approach to develop a survey that not only asked graduate students at Duke about their knowledge of certain transportation services but also about additional barriers to use of alternative modes.

Barriers of added time, a lack of convenience, and a lack of safety were identified in the survey in addition to generally low knowledge of transportation services at Duke. This largely aligned with information gathered through the literature review and interview components of this study. Respondents also indicated a preference for receiving information through student-wide e-mails. Based on this result, the researchers plan to create informational materials that can be systematically distributed to different graduate student populations at Duke. These materials will

spread information on specific transportation services and offer solutions to identified barriers to use of alternative modes.

This research could have implications beyond Duke. It could bring awareness to the need for informational campaigns in the alternative transportation space. If future data show an increase in alternative mode share among graduate students at Duke after viewing the prepared materials, this informational model should be employed by other universities aspiring to decarbonize their transportation needs.

Although suggesting overhauls of services at Duke is outside of the scope of this project, responses to the open-ended survey question revealed that students would like to see improved pedestrian infrastructure and bus routes on and around Duke's campus. Such changes could reduce the incidence of single-occupancy vehicle commuting. Perhaps a future research project could focus on the viability of addressing student concerns and improving offered services and the built environment.

As alluded to in the discussion, one limitation of this study is it was conducted during the COVID-19 pandemic. Transportation habits and barriers may change moving forward as Duke and the rest of the country move past the peak of the pandemic. Accordingly, similar research should be conducted after student life at Duke returns to some degree of normality to validate these results.

The data from this project reiterate that it is imperative to continue to search for creative methods to promote alternative transportation. Alternative modes have been lacking on Duke's campus, at other universities, and in most cities in the country for some time, and the COVID-19 pandemic has complicated mobility patterns for all these institutions. Times of crisis, however, exist as times of opportunity for changes to the status quo. With that in mind, it is hoped that the lessons and materials developed from this project can help propel Duke into a new era in which the university more effectively disseminates information that supports alternative transportation and assuages concerns surrounding these modes. Realization of the university's Climate Action Plan is dependent on this occurrence.

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**X. Appendix**



Figure A1. Targeted Informational Courses Have Left University of Rochester Students Comfortable Riding Bicycles Even in the Snow



Figure A2. References to Bicycle Transportation Permeate All Aspects of Colorado State's Campus



Figure A3. Colorado State has Committed to and Implemented Complex and Popular Bicycle Infrastructure on Campus

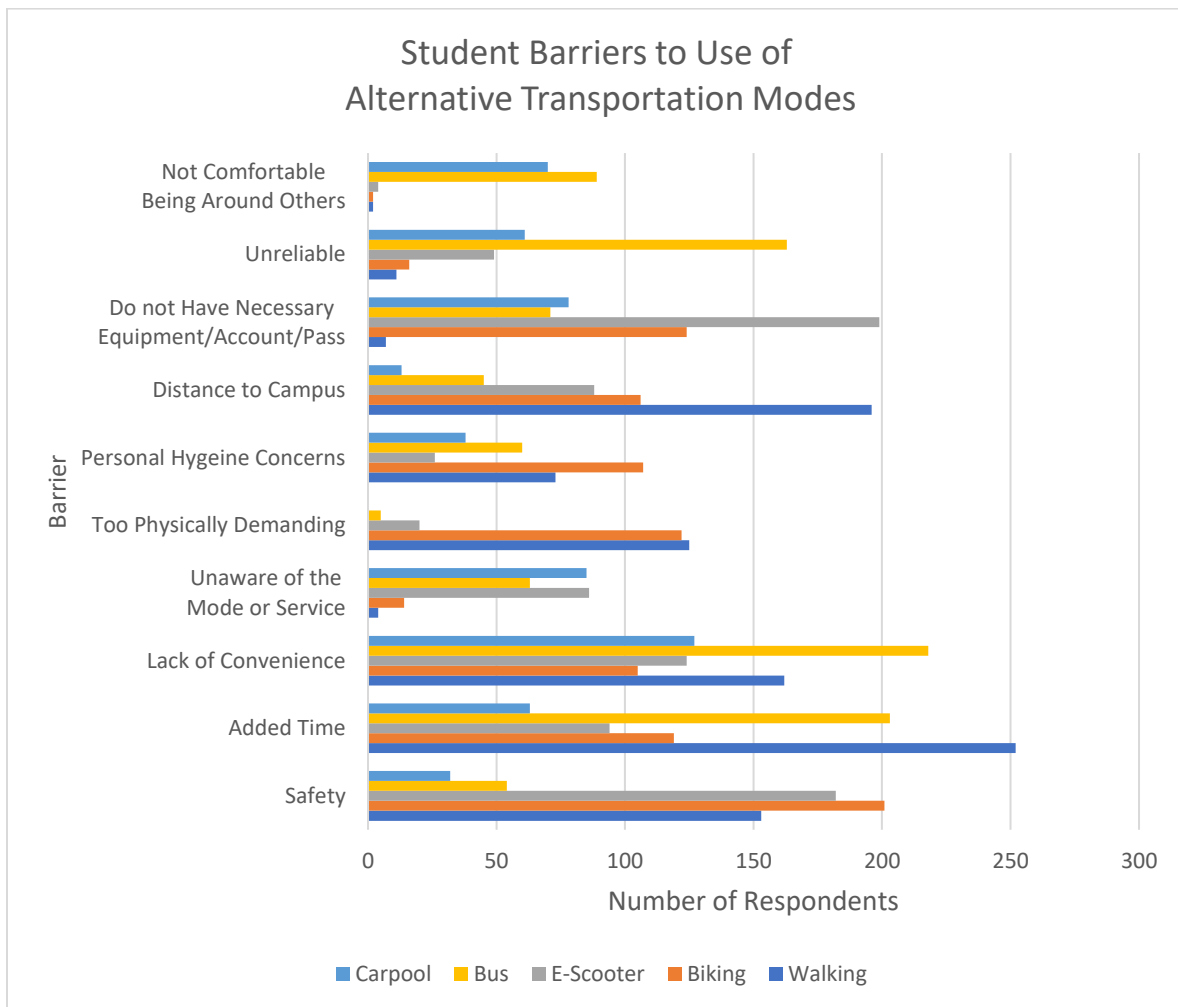


Figure A4. Full List of Barriers to Respondent Use of Alternative Modes to Commute to Duke University's Campus

