Longitudinal Analysis of Changes in the Behavior and Attitudes of College Undergraduates Toward Public Transportation: First and Second Wave Findings

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Disclaimer

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ABSTRACT

Understanding the attitudes and perceptions of a community's members towards public transportation is valuable when designing and delivering service. In this paper, the design and descriptive statistics for the first two waves of a longitudinal study of students enrolled at North Dakota State University are presented. The use of a longitudinal as opposed to a traditional cross-sectional survey instrument provides the ability to identify individual changes in attitudes and behaviors instead of relying on aggregate results, which often mask important differences that occur over time. Analysis of first-year data using a binary probit model finds that vehicle access, on-campus residence, prior transit use when traveling, and use of transit by family and friends significantly influence ridership behavior. Ridership by members of the survey cohort increased from 33% during their freshman year to 45% during their sophomore year.

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1. INTRODUCTION

Information drives decision-making. With accurate, timely information administrators can plan and manage their systems to efficiently meet its goals. However, it is common for information to go uncollected or not be fully incorporated into the decision-making process. This holds true in public transportation where the existing demands of operating a system oftentimes preclude its leadership from collecting and analyzing data due to the high cost.

While many public transportation firms employ ridership surveys, few investigate why riders have chosen public transportation as their mode of choice and how their behavior changes over time. Such in-depth surveys often require more time and financial resources than transportation agencies are able to dedicate. Repeating such surveys over time to track changes in attitudes toward and use of public transportation for the same individuals is even more costly and rare.

Despite its general absence, there is significant value to using longitudinal as opposed to cross-section data. While the benefits to a local public transportation agency alone may not justify the cost, using the information to drive public policy or to transfer its findings to other transit agencies may make the process worthwhile. In this paper, a description of the preliminary work and interim findings of a longitudinal survey focused on investigating the changing attitudes and behaviors of university students towards public transportation are presented.

The Fargo-Moorhead metropolitan area is a growing, vibrant community with more than 160,000 residents located on the Red River of the North, which divides North Dakota and Minnesota. In addition to being a medical, retail and entertainment center, Fargo-Moorhead is also home to three institutions of higher learning: North Dakota State University (NDSU), Minnesota State University, Moorhead (MSUM), and Concordia College, which together have over 22,500 students. Many of the students attending the three campuses regularly use public transportation, especially to and from campus, though intercampus trips are also common.

North Dakota State University is a land grant university located in Fargo, N.D., as such it offers a wide range of coursework from agriculture to engineering, from education to health to both large undergraduate and graduate student bodies. NDSU has seen its enrollment increase dramatically over the past decade and recently saw the addition of a downtown campus, which is home to its art and architecture students though courses for other departments are also offered at that location. This second campus has triggered an increase in the use of public transportation as it has become the predominant mode of travel between the two campuses.

The student population at NDSU is relatively dichotomous with large portions of the student body from rural areas in North Dakota and northwestern Minnesota and others from metropolitan regions, particularly the Twin Cities of Minneapolis and St. Paul, Minnesota. The familiarity with and use of public transportation between the two groups of students is likely quite different. The experience of many new university students is limited to school transportation or mass transit used when visiting major metropolitan areas.

A large number of students, mostly upperclassmen, reside off-campus. However, most of these students travel by their own automobiles to and from campus. A number of public transportation users live in the neighborhoods adjacent to the main campus and use it to travel between their classrooms and residences.

1.1 Previous Survey Instrument

Beginning in the spring of 2003, the Small Urban & Rural Transit Center in partnership with Metropolitan Area Transit (MAT), Fargo-Moorhead's public transportation provider, surveyed students attending NDSU, MSUM, and Concordia College to gain an understanding of their perceptions and use of the system. Each spring students were invited by email to complete a survey with approximately 5% of the students on each campus participating.

The absence of sampling did not appear to adversely affect the quality of responses during the first two years of the survey. However, responses from the most recent survey, conducted in the spring of 2005, show strong evidence of self-selection, as there was a significantly disproportionate number of female respondents from Minnesota State University-Moorhead and Concordia College relative to the actual student body. At the two campuses 88 and 81% of the surveys were completed by females, though they made up only 61 and 63% of their respective student bodies (Ripplinger and Ulmer 2005). Fifty-eight percent of the respondents from NDSU were female, while they only made up 45% of the student body.

This led to a re-evaluation of the survey design that resulted in a decision to pursue the development of the longitudinal survey instrument described in this paper. The first alternative considered was to continue using a cross-sectional survey, this time sent to a random sample of students. This option would increase the cost of the survey, but eliminate the problem of self-selection. However, it would still not provide the ability to track changes in individual student behavior.

1.2 Benefits and Costs of a Campus Transit Longitudinal Survey

A number of benefits and costs arise from longitudinal survey analysis as opposed to cross-sectional analysis. In the case of the campus transit survey, the pivotal issue is being able to determine the time of changes in attitude or behavior for each survey respondent. Similarly, longitudinal surveys minimize recall bias as participants are asked to recall events within the past year as opposed to longer periods of time. Longitudinal surveys are also of value statistically. Most importantly, they reduce sampling variability, allowing one to have smaller sample sizes to draw inferences. They also help reduce the cost of collecting the same introductory personal information each year, which for the campus transit survey is quite cumbersome.

The ability to identify changes in behaviors and attitudes is especially valuable for the campus transit survey as most students at North Dakota State University have limited experience with and knowledge of public transportation perhaps. To track these changes at a period of time when complex attitudes about personal mobility are just forming is sure to provide important information to policy analysts in addition to local transportation providers.

Significant concerns from pursuing longitudinal surveys include the high cost of repeated surveying and the loss of respondents due to attrition. The cost issue is not particularly relevant in the case of the campus transit survey, as its cross-sectional form was expected to continue to be used in the near term. The issue of attrition plays an even larger role in the campus transit survey, due to student departures from the university, an issue that is discussed later in the paper.

Oftentimes appropriate methods for dealing with attrition are ignored. Analysis of the data may not be possible for long periods of time, as adequate data may take years to collect.

1.3 Survey Objectives

The goal of the campus transit survey remains to identify attitudes towards and use of public transportation by college students. Of increased importance is the ability to identify changes in individual student's ridership patterns and attitudes towards various community and service characteristics. It is expected that the data collected allow for the same descriptors of service and perceptions currently possible with the campus transit survey in addition to its added inter-temporal capabilities. The use of a scientifically selected sample will also allow for an increase in the amount of statistical rigor used to analyze the data.

1.4 Population of Interest

The 2005 incoming class of freshman at North Dakota State University is the population of interest to the survey. In other words, the population universe is defined at the time of sample selection and is the incoming cohort of first-year students. No additions to the sample will be made once the final sample is made.

The data to be collected during the course of the survey will be similar to that currently collected by the campus transit survey. It will differ, as certain data will not need to be recollected each year. As with the current survey, there will exist a repeated set of core questions related to students' use of and perceptions of public transportation and related issues such as travel demand, vehicle access, parking, and MAT service and service quality.

Data was collected during spring 2006 and 2007. The final wave will be conducted in spring 2008 in what will be the spring of the senior year for students making regular progress through their bachelor's degree programs. Initial invitations to complete the survey online were extended via email as has been done in the past with relative success. Individuals who do not respond received a follow-up email reminder. Next, a phone call reminder and the offer of a telephone interview is provided. Students are able to opt out of participation at any time. Depending upon the determined sample size, these individuals will be either ignored or replaced.

1.5 Organization of the Paper

This report presents the sampling and survey methods and interim findings of the study. A description of the sample size method is presented in Chapter 2. Chapters 3 and 4 present descriptive statistics of the first two waves of the analysis. Chapter 5 presents the methods and results from applying binary probit modeling techniques to estimate the impacts of select variables on bus ridership. The final chapter presents a summary of findings and next steps.

2. DETERMINING THE MINIMUM SAMPLE SIZE

Although a number of statistical techniques exist to accommodate longitudinal data with various characteristics, effort is often saved by sampling appropriately and efficiently. One of the primary issues is assuring the sampling methodology makes the best use of existing knowledge of the population. This can allow for smaller sampling sizes than would otherwise be necessary, resulting in less costly surveys.

While a number of characteristics are of interest in this study, one target variable, student ridership, is of particular importance. Being able to accurately and efficiently estimate the current number of riders and the change in ridership has significant pragmatic value, especially if the rationale for the behavior can also be identified with data collected by other parts of the survey.

Before moving on to the issue of sample size, the type of sampling needed, be it simple, stratified, or clustered. It is assumed that ridership varies by class and gender as supported by the results in Table 2.1. Consequently, simple random sampling is not an efficient sampling method. Also, as this study is able to identify every member of the 2005 freshman class, the need to cluster is also alleviated leaving stratified sampling as the method of choice.

Table 2.1 Difference of Mean Ridership by Gender

	T Statistic
Freshman	0.64
Sophomore	-0.44
Junior	-2.04
Senior	-1.57

To determine the minimum sample size needed for the longitudinal study, a modified version of a formula presented by Levy and Lemeshow (1999) is used. The formula assumes that we wish to find an estimated mean within 100 x ε percent of its true value for a given alpha level. The formula requires variance and mean estimates for each of the h strata, of which there are L total. In the following formula, N is the total number of units that could be sampled, and N_h is the total number of units of type h. $Z_{1-\alpha/2}$ is the value of the standard normal distribution while P_{hy} is the proportion of the population in strata h with the desired trait, and P_h is the proportion of the population in strata h.

$$n \approx \frac{\left(\frac{z_{1-\alpha/2}^2}{N^2}\right)\left(\sum_{h=1}^{L}\frac{N_h^2 P_{hy}\left(1-P_{hy}\right)}{\pi_h P_y^2}\right)}{\varepsilon^2 + \left(\frac{z_{1-\alpha/2}^2}{N^2}\right)\left(\sum_{h=1}^{L}\frac{N_h P_{hy}\left(1-P_{hy}\right)}{\pi_h P_y^2}\right)} \quad (1)$$

Π_h is an allocation weight, calculated using the formula (2). In addition to being used in (1), the value will also be used later to determine the number of individuals who should be sampled from each strata.

$$\pi_h = \frac{N_h\sqrt{P_{hy}(1-P_{hy})}}{\sum_{h=1}^{L} N_h\sqrt{P_{hy}(1-P_{hy})}} \qquad (2)$$

Values of n are calculated for each of the four classes. These values are then multiplied by the respective retention rate. The largest product, n*, is the minimum sample size for the longitudinal survey.

$$n^* = \max(r_1 n_1, r_2 n_2, r_3 n_3, r_4 n_4) \qquad (3)$$

Table 2.2 presents the data and results for determining the sample size for the campus transit longitudinal study based on values from the Spring 2005 Campus Transit Study. The retention rates are meant to parallel the expected rates experienced by the 2005 incoming freshman class. An alpha level of .05 and an ε of .2 are used in the calculations. The largest value of 110 is found for the senior class, meaning that at least that number of students should be selected based on the data from the previous campus transit cross-sectional study. It is expected that the actual number of students surveyed will exceed this value.

Table 2.2 Minimum Sample Size Calculations

	Female		Male		Retention Rate	r n
	Sample Mean	Sample Variance	Sample Mean	Sample Variance		
Freshman	0.5	0.25	0.44	0.25	1	59
Sophomore	0.39	0.24	0.42	0.24	0.8	92
Junior	0.37	0.23	0.54	0.25	0.7	88
Senior	0.43	0.25	0.54	0.25	0.65	110

This minimum sample size, 110, is then multiplied by the allocation weights, π_h, to find the optimal allocation of the sample to each sex. For the data used, 61% or 67 of the individuals sampled should be female, the remainder, 39%, or 43 individuals, should be male as shown in equations (4) and (5). These values may be skewed to some degree due to the high response rates of females in the previous survey.

$$n_f = n^* \times \pi_f = 110 \times .61 = 67 \qquad (4)$$

$$n_m = n^* \times \pi_m = 110 \times .39 = 43 \qquad (5)$$

One of the most significant challenges resulting from transitioning from a traditional cross-sectional survey to a longitudinal one is the issue of attrition, which was accommodated with the introduction of retention rates in the previous calculations. Though nearly all longitudinal surveys suffer from increasing nonparticipation during later waves, attrition in this study is of additional concern due to the expectation of significant numbers of students withdrawing from the university prior to the study's completion. Fortunately, the longitudinal campus transit survey benefits from the fact that it is a relatively short-lived, three year survey.

Attrition is usually of concern, as it introduces bias into the estimates. This effect is greatest when there is a correlation between attrition and the variables of interest. It seems logical that attitudes towards and use of public transportation are weakly correlated with attrition in the population of interest. That is, students who leave the university or are unable to be contacted at future dates are no more or less likely to respond a certain way to any of the variables of interest. In the next two chapters, descriptive statistics for the first two waves of the study are presented.

3. FIRST WAVE RESULTS

The first wave of the survey collected data from 231 freshman students at North Dakota State University (NDSU). These students represent approximately % of their freshman class during the spring 2006 academic semester, 2,301 students. The male to female distribution is 47% female and 53% male, a slight deviation from the total class proportion of 52% male and 47% female. The majority of respondents, 6%, are nineteen years old, followed by 29% at eighteen years of age (Figure 3.1).

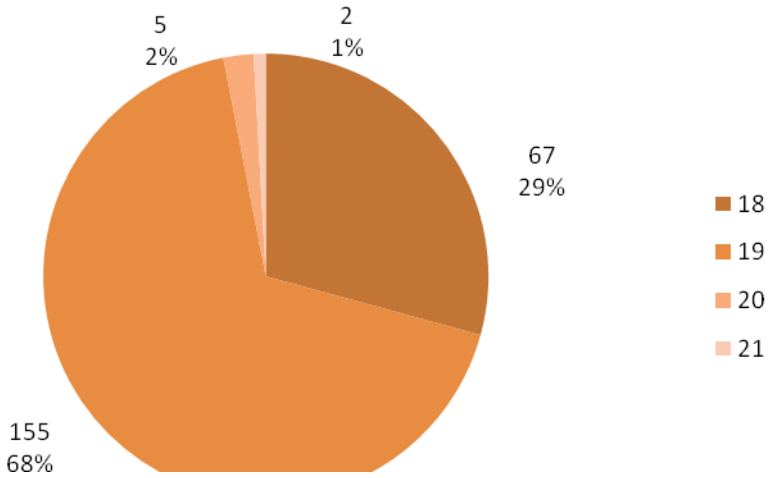

Figure 3.1 Distribution of First Wave Respondents by Age

3.1 Previous Use of and Attitude Toward Student Transportation

Many incoming university students have significant experience as riders on student transportation systems. One hypothesis is that this experience may influence their decision to use public transportation while at college. A series of survey questions asks students about their prior use and attitude toward student transportation.

3.1.1 K-12 Regular School Bus Rider

Regular use of the school busing system is reported by 76% of the survey respondents. Eight years of ridership is most reported by respondents followed, closely by nine years with a one student difference (Figure 3.2).

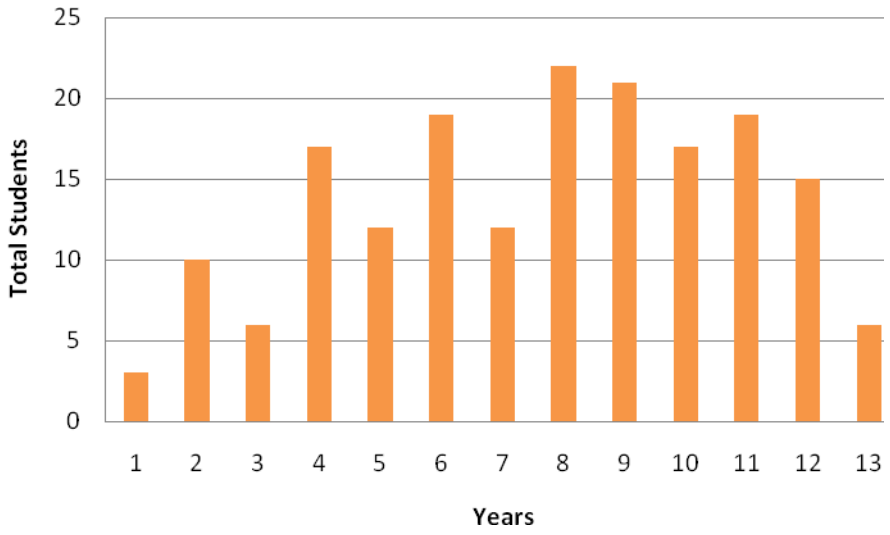

Figure 3.2 Years of Student Transportation Use

3.1.2 Route Characteristics

During the students' years of student transportation ridership, the prominent routes traveled included rural routes for 50% of students, urban for 33%, and 17% with a combination of both (Figure 3.3).

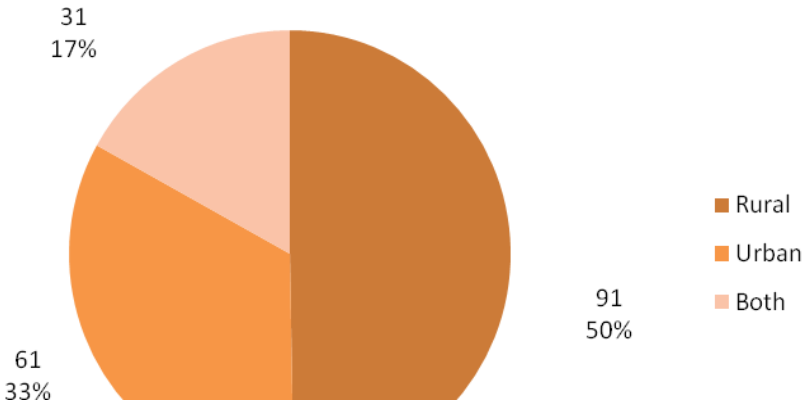

Figure 3.3 Student Transportation Route Characteristics

As for one-way trip length, the top three response categories account for 96% of student travel with 61% less than 10 miles, 23% between 11 and 20 miles, and 12% 21 to 30 miles (Figure 3.4). The remaining 4% consists of 3% divided evenly among 31 to 40 miles and 41 to 50 miles and 1% divided equally between 61 to 70 miles and 71 to 80 miles.

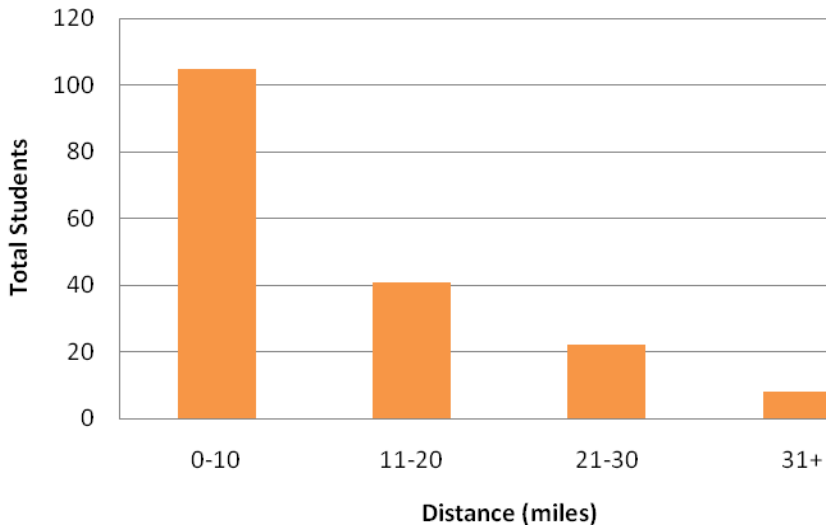

Figure 3.4 One-way Trip Lengths

Overall, when asked to indicate their agreeableness regarding the categories of comfort, cleanliness, convenience, reliability, and friendliness of drivers, 12% strongly agree and 53% agree with those statements about their student transportation systems (Figure 3.5). Similar to the averaging of all groups, every category has a majority of students agree with the statements. Reliability and the ability of the bus to remain on time is strongly agreed upon by 18 % of respondents and agreed upon by 62%. Similarly, the overall convenience of using the bus as a mode of transportation to and/or from school is strongly agreed upon by 19% and agreed upon by 54% of students. Bus cleanliness took a slight tip with only 5% of students strongly agreeing and 45% agreeing. Likewise only 5% strongly agree and 51 % agree that the bus is comfortable.

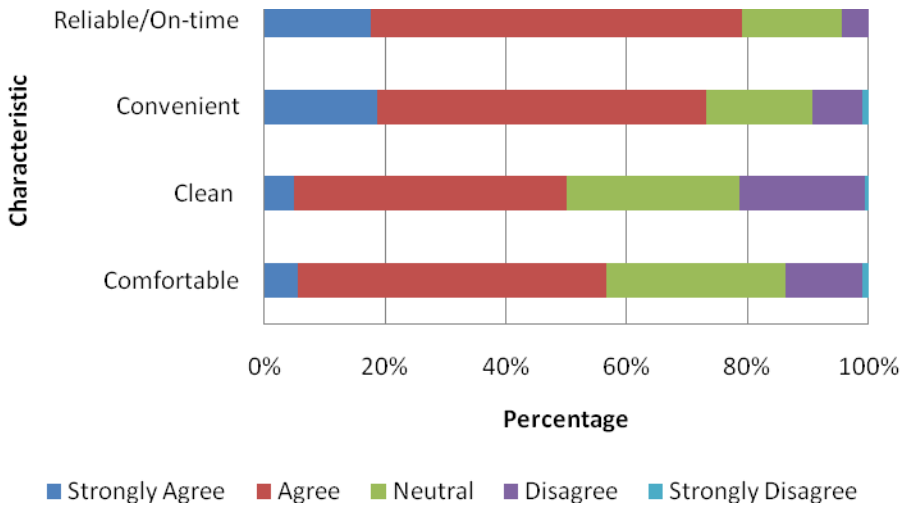

Figure 3.5 Student Transportation Busing Characteristics

High school activities that require bus travel is reported by 91% of respondents. Of those, 60% report having a dedicated bus; 50% of which are motor coaches.

The experience of bus transportation when rated on driver friendliness, reliability, convenience, cleanliness, and comfort are strongly agreed upon by 20%and agreed upon by 52% of student respondents (Figure 3.6). Individual categories receive similar ratings with the majority of responses in agreement. The activity bus' ability to remain on time and reliability is strongly agreed upon by 19% and agreed upon by 61% of respondents. Convenience is rated the highest, as 24% of students strongly agree and 58% agree. Cleanliness and comfort are below all other categories for ratings in strongly agree and agree. Cleanliness was 14% for strongly agree and 44% for agree, and comfort was 15% in strong agreement and 48% for agreement.

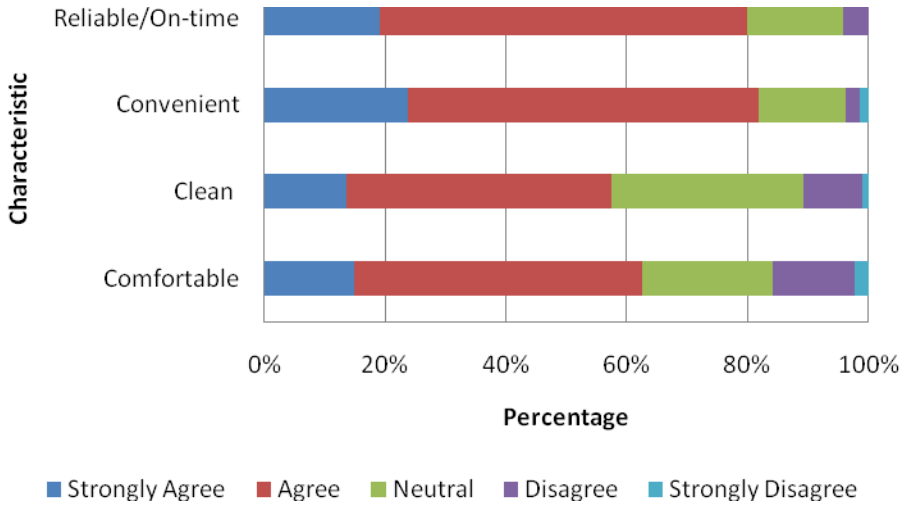

Figure 3.6 Characteristics of the High School Activity Busing Experience

3.2 Previous Use of and Attitude Toward Public Transportation

Most matriculating freshmen have some type of experience with public transportation either as riders or having friends or family members who do. These attributes may play a role in campus transportation ridership while at North Dakota State University. A series of survey questions asked students about their prior use and attitude toward public transportation.

3.2.1 Available Public Transportation in Hometown

Sixty-one percent of survey respondents indicate their previous residence included busing as a form of public transportation, followed by 31% with demand-response buses (Figure 3.7).

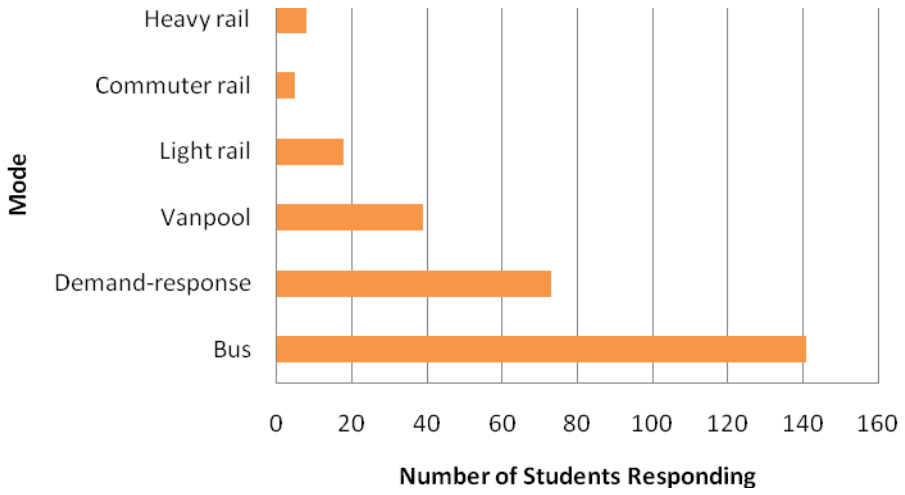

Figure 3.7 Transportation Available Within Students' Previous Residence

3.2.2 Usage of hometown transportation

While bus systems are reported as the most widely available transportation mode, only 30% of students report use of it. Figure 3.8 represents the percent of students using the transportation available based on the total number of students reporting the service.

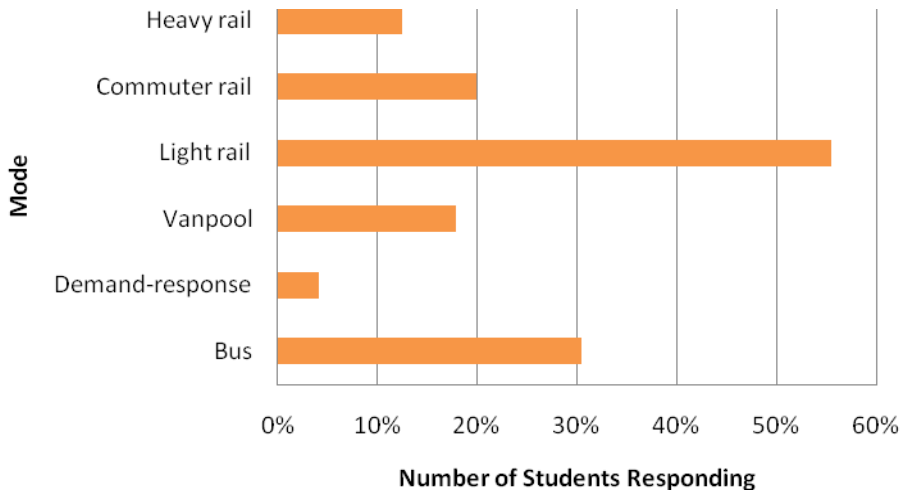

Figure 3.8 Student Usage of Hometown Public Transportation Modes

The mode of transportation with the highest reported frequency of use is buses with usage reported from once to daily. The characteristics of the bus are strong as 20% strongly agreed, 58% agree and no responses are given for strongly disagree (Figure 3.9). Individually, each category yielded a unique set of responses. More than 62% of respondents agree or strongly agree that the driver is friendly. Reliability was split between 38 %t strongly agreeing and 62%

agreeing. The affordability of bus transportation is strongly agreed upon by 26 % and agreed upon by 42%. Convenience is rated with 16% strongly agreeing and 61% agreeing. Cleanliness only receives 7 percent in strong agreement, but does receive 72% in agreement. Comfort rates even lower with only 4% with strong agreement and 65% in agreement. Taking someone where he or she wants to go is strongly agreed upon by 18% and agreed upon by 54%. Finally the easiness of use is strongly agreed upon by 17% and agreed upon by 69%.

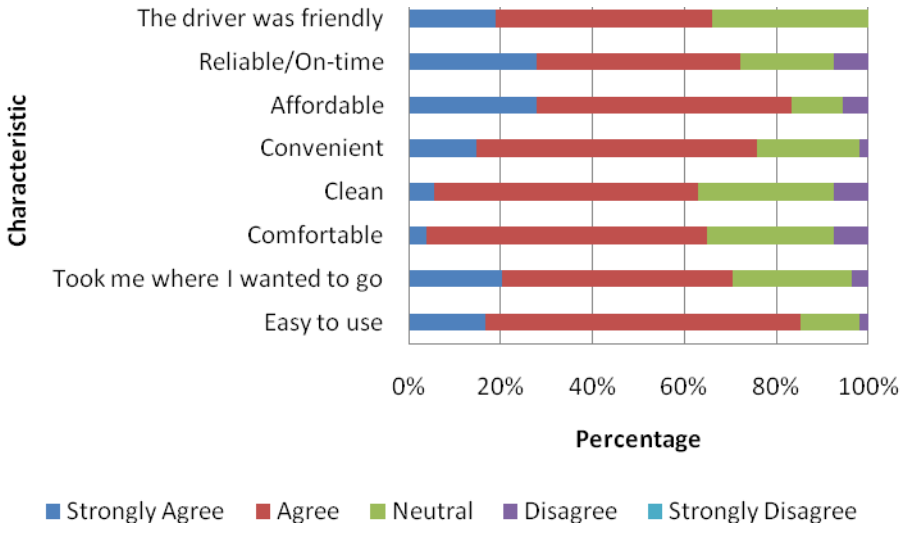

Figure 3.9 Characteristics of the Bus Systems

3.2.3 Demand-Response Bus Experiences

Demand-response buses experience minimal usage ranging from once to twice per month. The mode received lukewarm reception with a majority, 59%, of characteristic ratings in neutral and only 8% strongly agreeing and 29% in agreement (Figure 3.10). Category specific driver friendliness is divided between agreement at 17% and neutral at 83%. Reliability or its ability to remain on-time is strongly agreed upon by 17% and agreed upon by 33%. Affordability is split with 33% strongly agreeing and 67% neutral. Convenience is almost equal, as 33% are in agreement and 67% neutral. Cleanliness is the only category to receive a ranking of strongly disagree at 17%, the additional rankings 33% in agreement and 50% neutral. Comfort similar to cleanliness is the only category to receive a disagreement response at 17% followed with 17% at agree and 67% neutral. Taking the individuals where they need to go has 17% in strong agreement and 33% in agreement. Finally, the ease of use is divided between 57% in agreement and 43% in neutral.

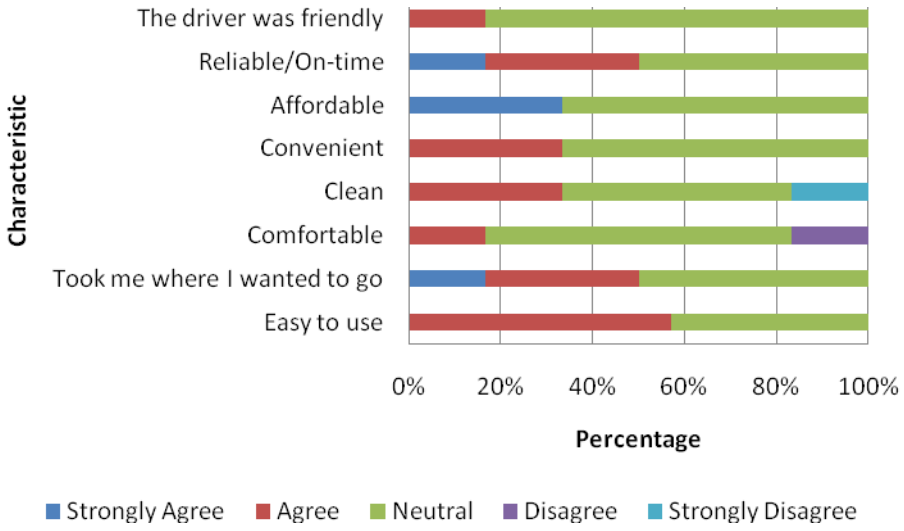

Figure 3.10 Characteristics of the Demand-Response Bus Systems

Vanpool system usage is a few times per month with 10% of category responses strongly agreeing, 46% agreeing and nothing below neutral (Figure 3.11). Driver friendliness incurs a three way tie with 33% from strongly agree, agree, and neutral. Reliability has 11% in strong agreement and 56% in agreement. Affordability is divided between 22% in agreement and 78% neutral. Convenience of using a vanpool is strongly agreed upon by 11% and agreed upon by 56%. Cleanliness ratings are shared between agreement at 44% and 56% neutral. Comfort is strongly agreed upon by 22% and agreed upon by 44%. As for taking the respondent where he or she wants to go, 67% in agreed and 33% are neutral. Finally, the ease of use is divided with 44% in agreement and 56% neutral.

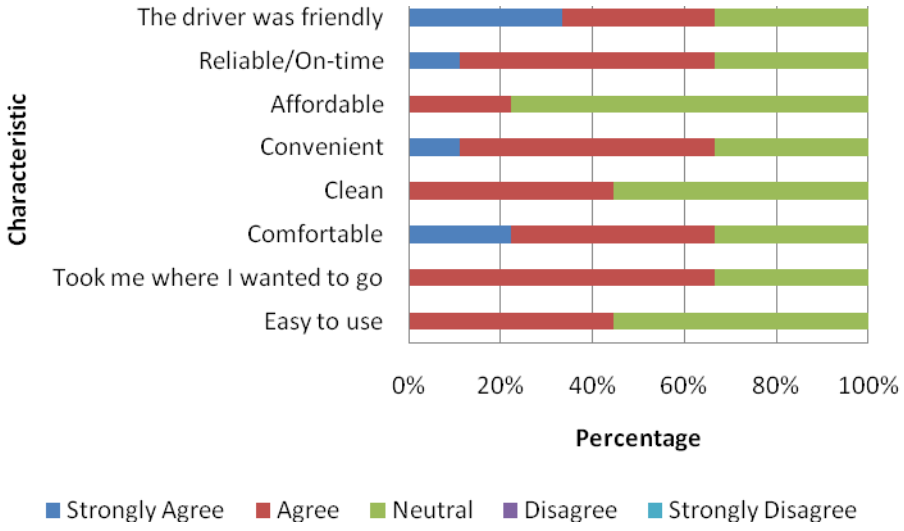

Figure 3.11 Characteristics of the Vanpool Systems

Similar to vanpool systems, light rail is reported with frequencies of use averaging a few times per month. Light rail is generally well-received by students with ridership experiences with the mode with 34% of responses in strong agreement with the category statement, 52% in agreement and no responses below neutral (Figure 3.12). Category specific driver friendliness is split between 27% in agreement and 73% neutral. Reliability and ability to remain on-time is composed of 45% in strong agreement and 55% in agreement. Affordability has 64% in strong agreement and 36% in agreement. Convenience is the same as affordability just reversed with 36% in strong agreement and 64% in agreement. Both cleanliness and comfort receive the same ratings with 27% in strong agreement and 55% in agreement. Taking the individual where he or she needs to go and the ease of use also has the same rankings, with 36% strongly agreeing and 64% in agreement.

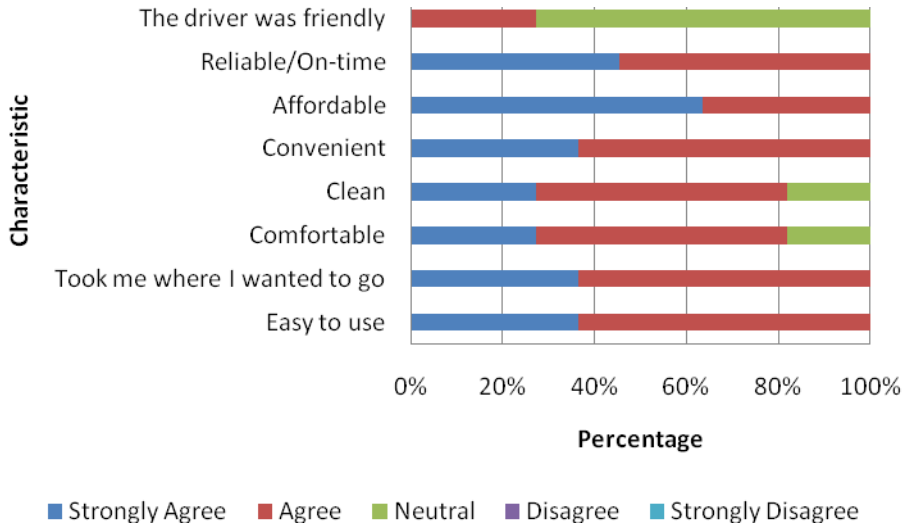

Figure 3.12 Characteristics of the Light Rail Systems

As for commuter and heavy rail, only one person reports use and characteristic ratings. Subsequently, those categories are omitted as they only represent one respondent's views.

3.2.4 Public Transportation Experiences of Friends and Relatives

Forty-three percent of students report family and friends using public transportation, with friends at 45% (Figure 3.13). The top response of friends is followed by extended relative and sibling/parent claiming almost a quarter each at 25 and 22%, respectively, with grandparents trailing at 8%.

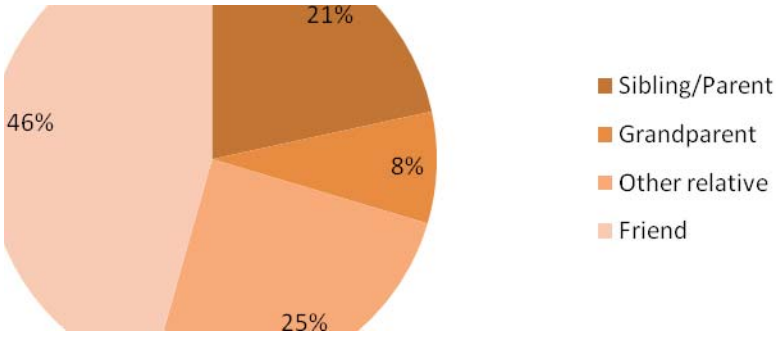

Figure 3.13 Percent of Students with Friends and/or Relatives using Public Transportation

Additionally, the modes of public transit used show 73% of friends and relatives using the bus with the second highest category of rail at 17% (Figure 3.14).

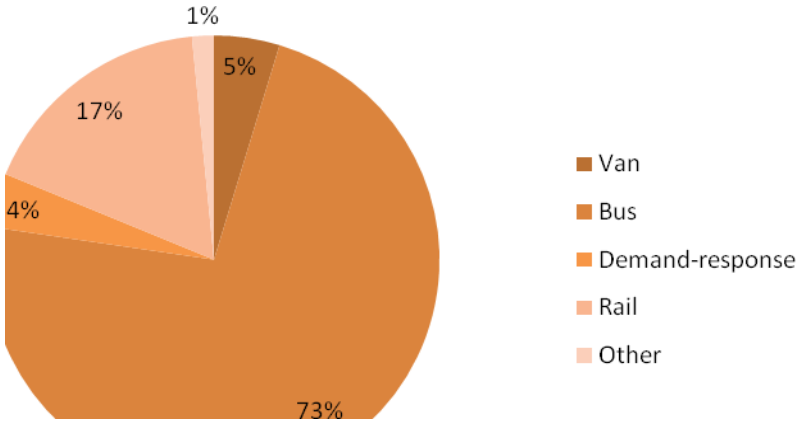

Figure 3.14 Mode of public transportation used by family/friends

3.2.5 Public Transportation Use while Traveling

During pervious traveling experiences students indicate use of several public transportation modes with bus being most regularly used (Figure 3.15). While there is a significant 'other' category, the primary response was a non-public transportation mode, airplane travel.

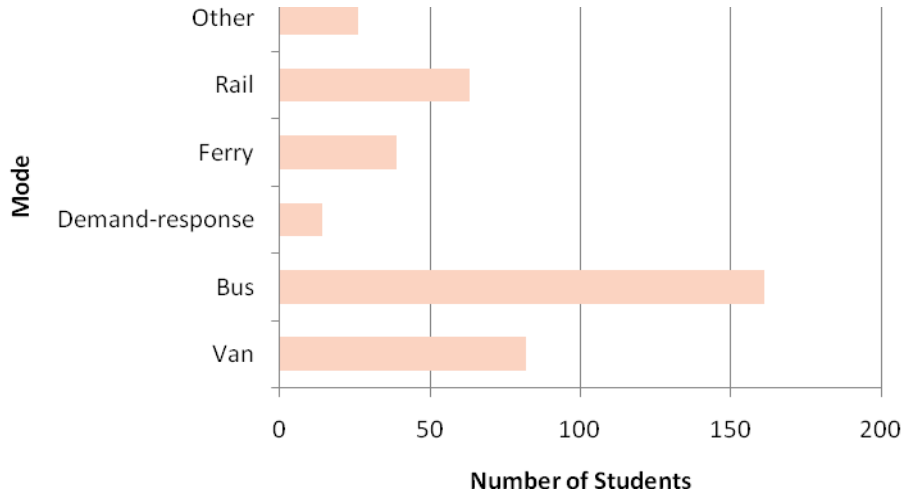

Figure 3.15 Types of Public Transportation Used for Travel

While traveling and using public transportation, the majority of respondents are satisfied with their experience, as 14% strongly agree and 63% agree with characteristics of their transportation mode (Figure 3.16). Independently driver friendliness receives 18% in strong agreement and 52% in agreement. The ability to remain on-time and its reliability is strongly agreed upon by 16% and 64% agreed. The affordability for public transportation is strongly agreed upon by 15% and agreed upon by 56%. The convenience of public transit is strongly agreed upon by 14% and 68% agreed. As for cleanliness, 10% strongly agree and 56% agree. Comfort was strongly agreed upon by only 7% and 64% agreed. Taking a person where he or she needs to go is strongly agreed upon by 18% and agreed by 71%. Ease of use is rated strongly agree by 17% and 72% agreed.

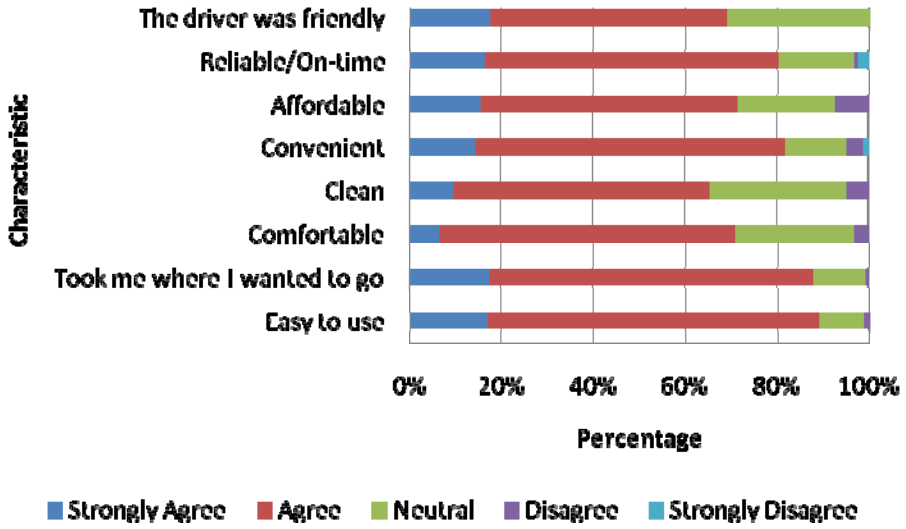

Figure 3.16 Rating Characteristics of Public Transportation

3.3 University and Travel Mode Selection

Decisions regarding residence and travel mode are usually considered to be dependent on one another and may or may not be made simultaneously. For the first wave of the survey, questions specific to location and travel mode selections were asked to investigate this issue.

3.3.1 NDSU's Location

Of the respondents, 71% state the location of NDSU is a factor in their enrollment. Additionally, 83% of students resided outside of the Fargo-Moorhead area prior to entering college. For those students, Figure 3.17 displays their one-way trip distance between home and NDSU. A travel distance of 151 to 200 miles was the top response area, followed closely by 0 to 100 miles with a one person difference.

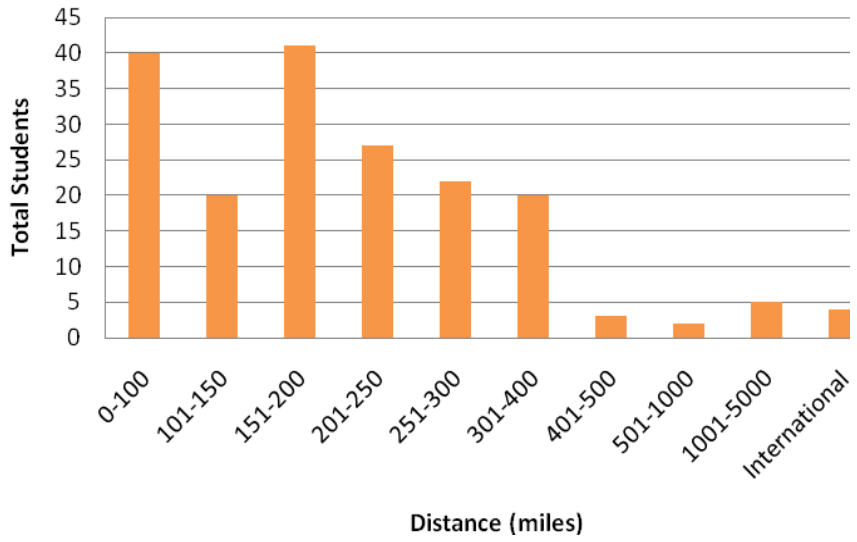

Figure 3.17 Distance from Students' Hometown to NDSU

3.3.2 Visiting Previous Residence

When visiting their previous residence, the mode of transportation used is generally the same as expected (Figure 3.18). The differences experienced between anticipated and actual involved a 2% increase in automobile travel. Motorcycle usage increases by one person, while bus travel increases by 38%. Subsequently, carpooling increases by 5%, while rail experiences a 6% increase. Airplane travel remains constant, and the other category increases by one person. The modes listed for the other category includes semi-truck and friends, the latter of which implies carpooling.

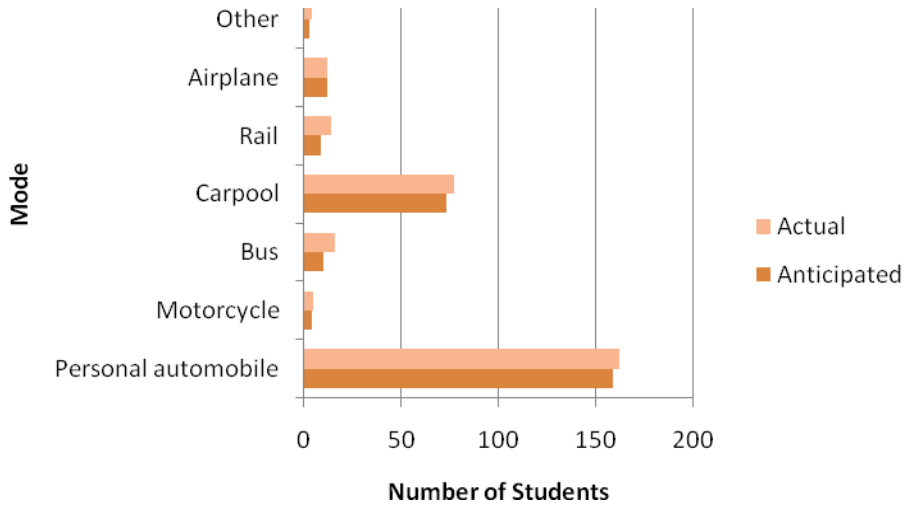

Figure 3.18 Anticipated Versus Actual Transportation Method Used to Travel Home

3.3.3 Gasoline prices

Despite historically high gasoline prices, 60% of the students declare that the price of gasoline has not affected the number of times they travel home. Additionally, 67% state that they have not adjusted their mode of transportation due to gasoline prices.

3.4 Life Events

3.4.1 Past six months events

Of fourteen possible life events, the event most frequently occurring is a change in academic major (Figure 3.19). This is followed closely by beginning a new job. The categories however of marriage, divorce, change of child care arrangements, and becoming a single parent do not receive any responses.

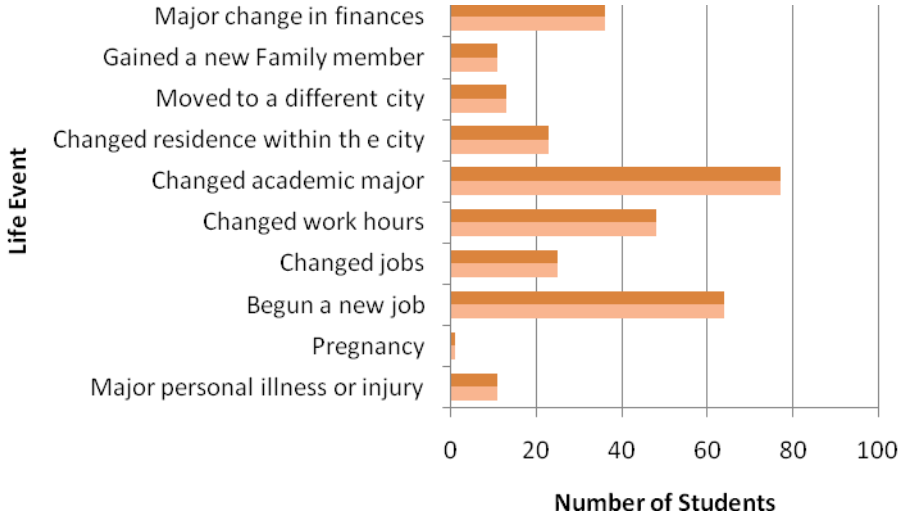

Figure 3.19 Number of First Wave Students Experiencing Particular Life Events Within the Past Six Months

3.4.2 Motor Vehicle Use During School

The majority of respondents, 77%, report having access to a motor vehicle while attending school.

3.4.3 Living situation

Of the respondents, 80% live on campus and the remaining 20% off campus. Sixty-one percent report that transportation to and from campus is not a factor in the housing decision. One factor; however, that is affecting their decision is NDSU Department of Residence Life housing policy requiring that any student under the age of nineteen reside on campus, with exceptions granted for students living with family and relatives on a case-by-case basis.

3.4.4 On-Campus Students

Of the 80% of students who elect to live on campus, the trip purpose most frequently reported for leaving campus is general shopping purposes (Figure 3.20). Visiting family and friends held 18% and entertainment at 16% accounting for 57% of responses and the top three answer categories.

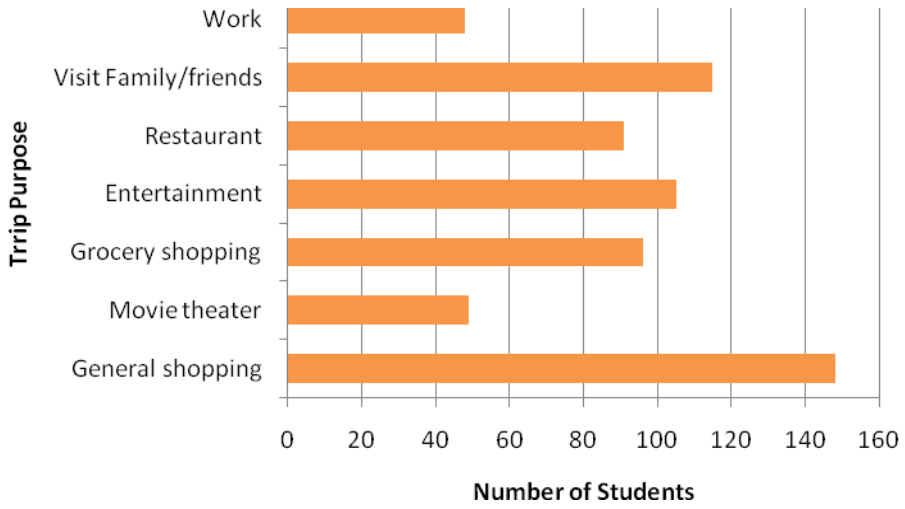

Figure 3.20 Reasons First Wave Students Residing on Campus Most Frequently Leave

3.4.5 Housing Location

Of the remaining 20% of students choosing to reside off-campus, 48% reside in North Fargo during this study period (Figure 3.21). South Fargo is the second most reported area at 28%.

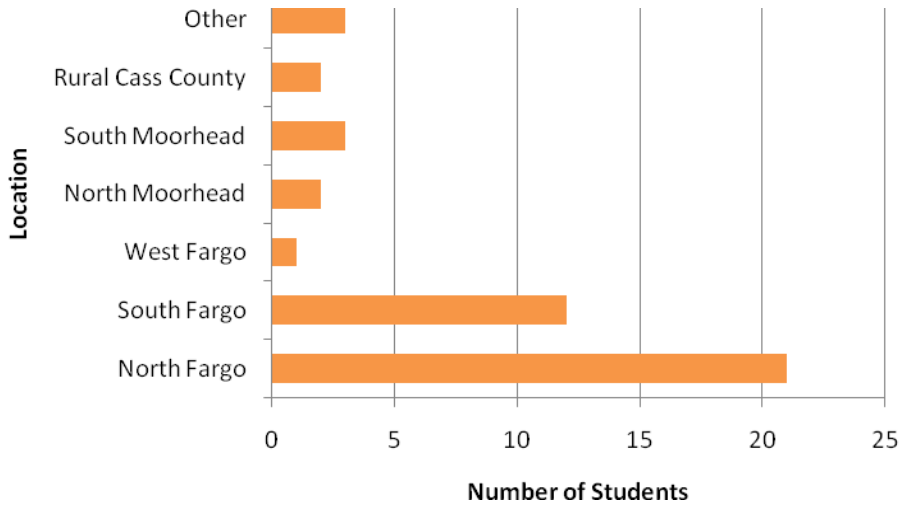

Figure 3.21 First Wave Student Housing Locations

The top three categories for one-way distance between campus and the students' residence consist of 33% less than a quarter-mile from campus, 30% over five miles, and 20% between two and five miles (Figure 3.22).

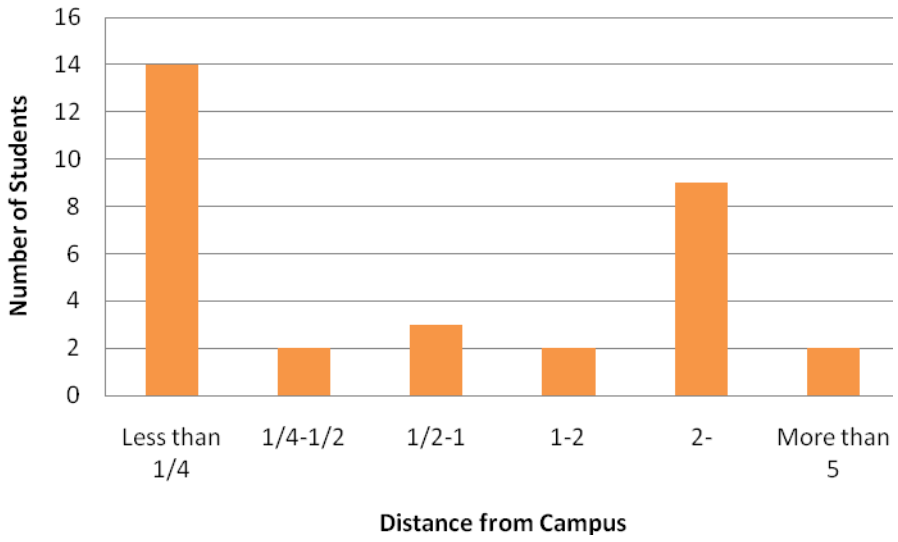

Figure 3.22 One-way Distance Between First Wave Students' Residence and NDSU

3.4.6 Times Frequently on Campus

Eighty percent of off-campus students are on campus between 8am and 4pm (Figure 3.23). The peak time frame occurs between 10 am and 2 pm, when 42% of all respondents are on campus.

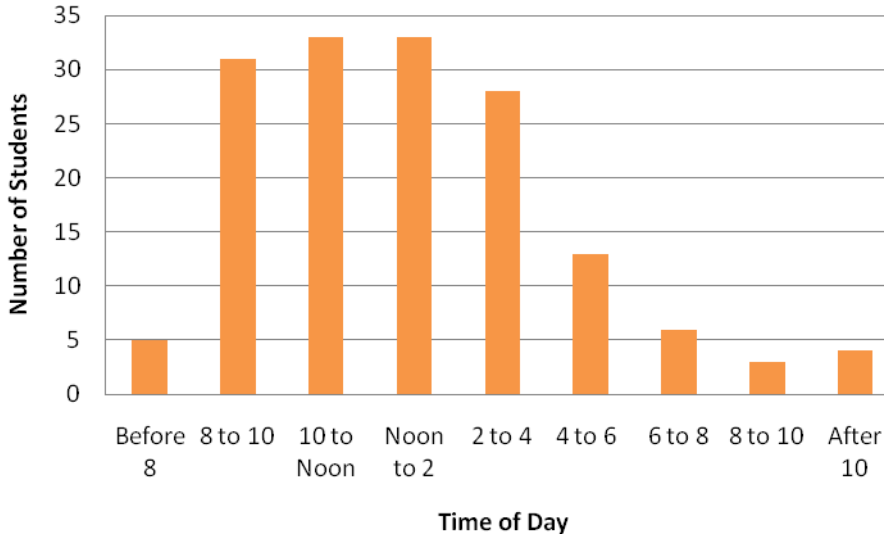

Figure 3.23 Periods in Which First Wave Off-Campus Students are Most Frequently on Campus

3.4.7 Travel to Campus

Ninety-six percent of students state when traveling to campus they are coming from their homes, while the remaining four percent is divided evenly between work and child care. Additionally, 76% of students make two one-way trips and 19% make four one-way trips, with the remaining 5% scattered between one and six trips per day (Figure 3.24).

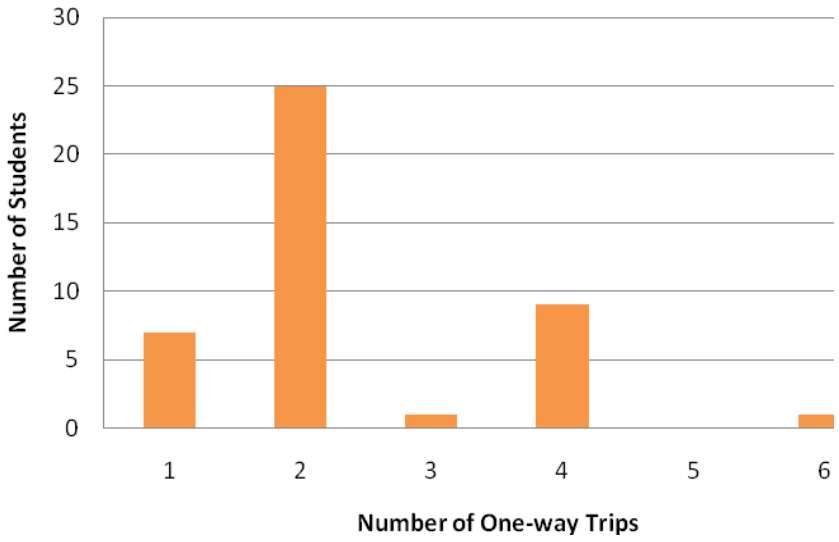

Figure 3.24 First Wave Students' One-Way Trips Between Home and Campus

The most common mode of travel is automobile at 52% ,with walking as the second highest category at 27% (Figure 3.25).

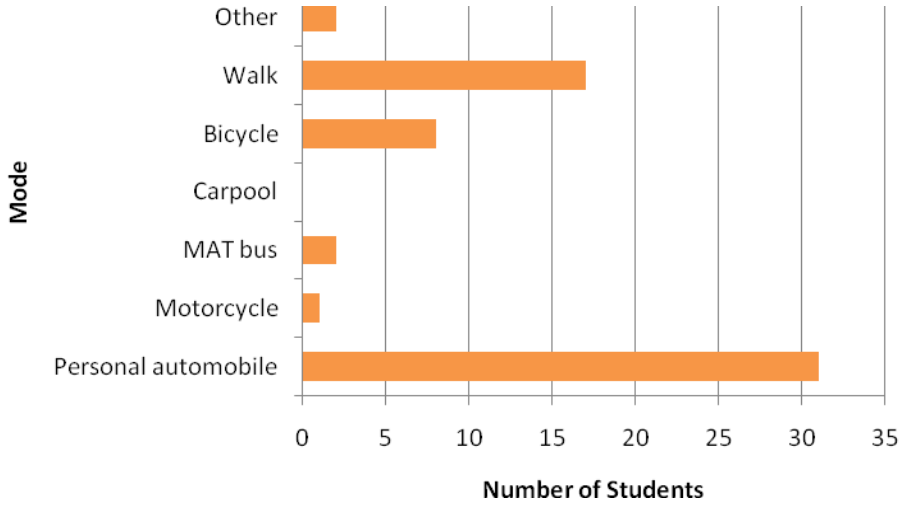

Figure 3.25 Modes of Transportation Used by First Wave Students to Get to Campus

Of the students using personal automobiles, 78% have a travel time of less than 19 minutes (Figure 3.26). Of that 78%, 36% have times of nine minutes or less and 42% have times of 10 to 19 minutes.

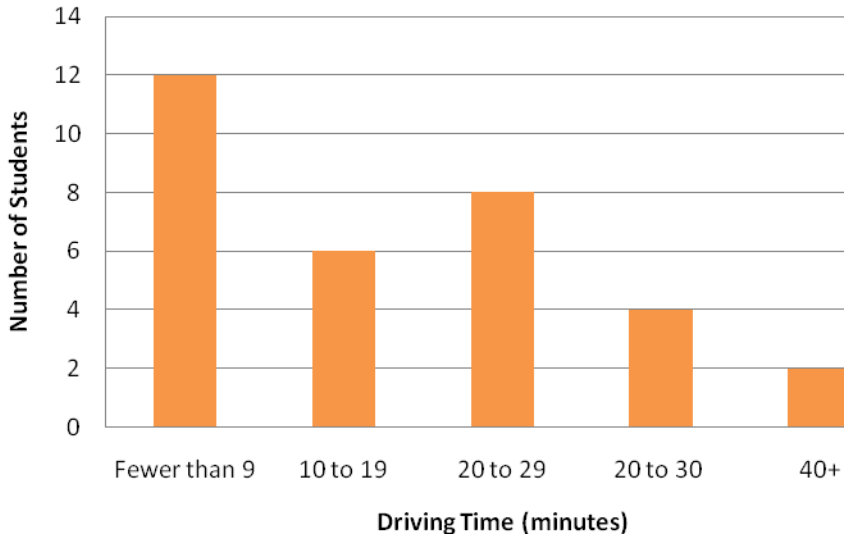

Figure 3.26 Travel Time for First Wave Students Using Personal Automobiles to Get to Campus

The top response regarding acceptable trip times for a bus ride between home and campus is will not ride at 30% (Figure 27). The next highest response iss 26% for less than nine.

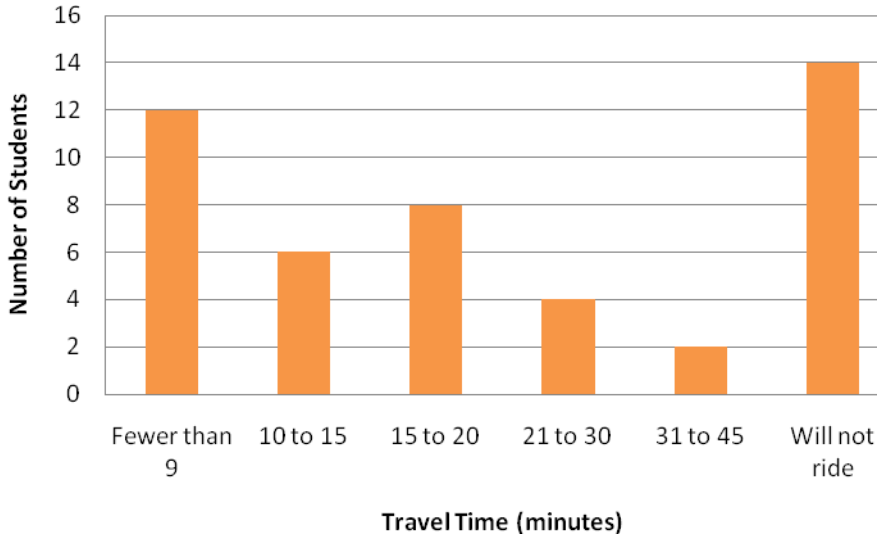

Figure 3.27 Acceptable Trip Time from Home to Campus by Bus (First Wave)

With the largest segment of students not willing to ride, the factors in mode selection become increasingly important to understand. When asked to rate the categories of time, parking availability, weather, cost of parking, cost of the vehicle, and convenience, 45% rate them as very important, while 35% as important (Figure 3.28). The time factor in mode selection is very important to 50% of students and important to 37%. Parking availability is very important to 37% and important to another 41%. Weather receives the lowest emphasis, with only 26% stating it is very important and 35% important. The cost to park receives 48% for very important and 35% for important. Similarly, the cost of a vehicle has 46% in strong agreement and 35% in agreement. Convenience is rated the highest with 63% stating that it is very important and 26% important.

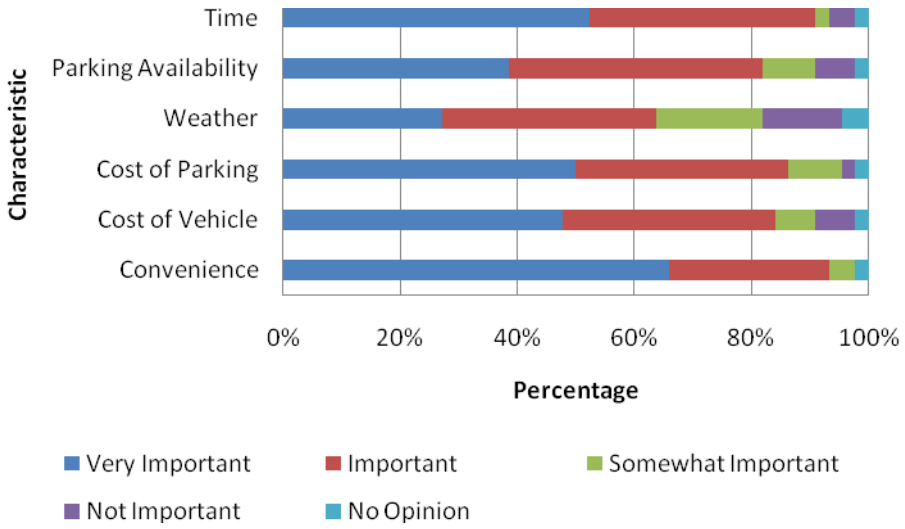

Figure 3.28 Factors Affecting Mode of Transportation Choices (First Wave)

3.5 Campus Parking

3.5.1 Current Parking Permit

Currently, 67% of the students state they have parking permits. However, of those students with a parking permit, only 21% occasionally park on the street. For the students with parking permits, the primary parking area is R-lot at 51% (Figure 3.29).

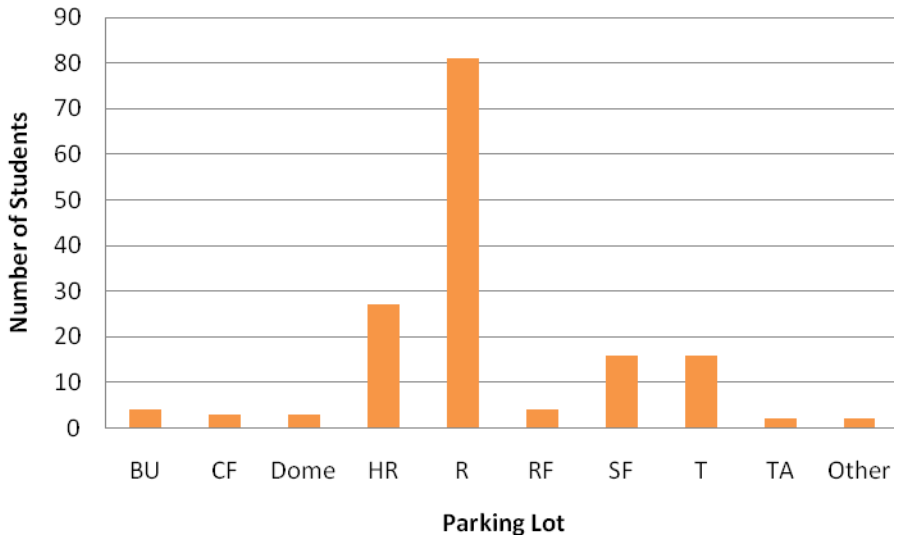

Figure 3.29 First Wave Students Parking Permit Locations

Additionally, for students holding parking permits 39% rate the convenience as fair and 30% as good (Figure 3.30).

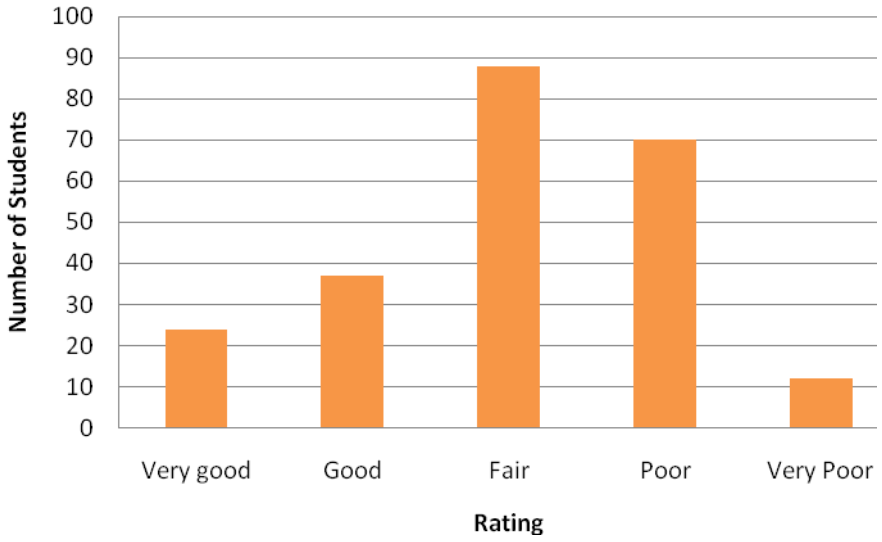

Figure 3.30 Rating Parking Permits Based on Convenience (First Wave)

Whereas parking permit affordability has 36% of students ranking it as fair, with another 14% rating it as poor (Figure 3.31).

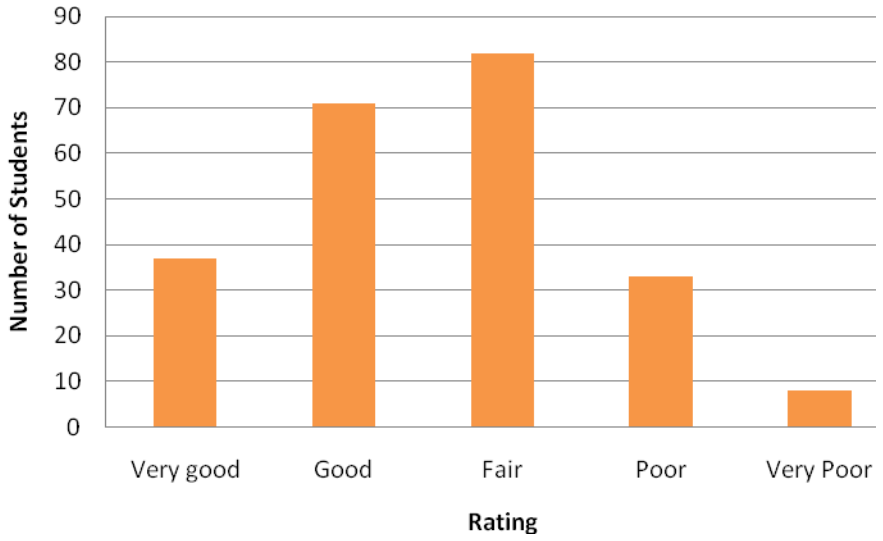

Figure 3.31 Rating Parking Permits Based on Affordability (First Wave)

As for the implementation of off-campus parking lots and adjacent bus routes, 72% of students would wait 15 minutes for a bus; however, only 25% of students would wait 30 minutes for the next bus.

3.6 Walking

A reasonable walking distance for 55% of students with the temperature below freezing is less than a quarter of a mile, and 90% state the distance should be less than half a mile (Figure 3.32).

On days when the temperature is above freezing, students state almost evenly that walking anywhere from a mile to a quarter of a mile is an acceptable distance (Figure 3.33).

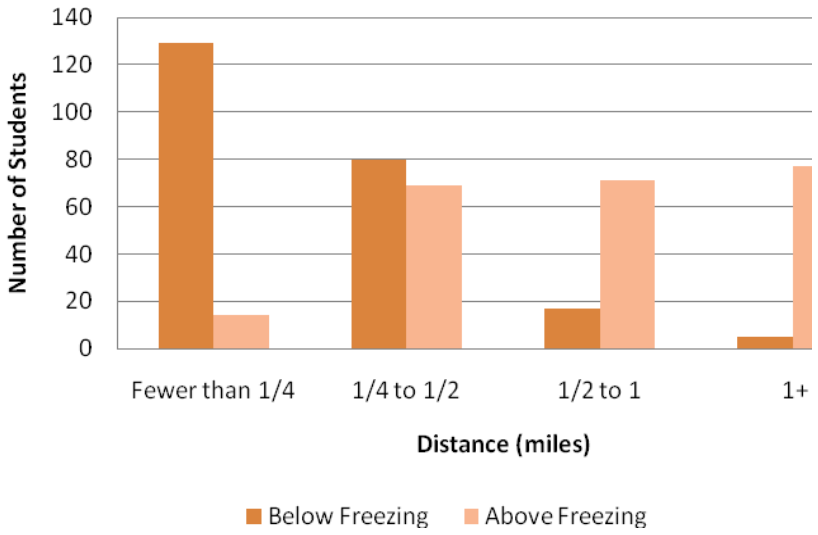

Figure 3.32 Reasonable Walking Distance for First Wave Students

While students are willing to walk, 20% state there are locations on campus too far to walk between. Locations yielding more than three responses are presented in figure 34. Due to close proximity of suggested destinations, they were grouped together to demonstrate a general area. The Minard, Music building, Askanses, and library combination is the highest response area at 37%, whereas the criminal justice building is the highest single location listed at 12%.

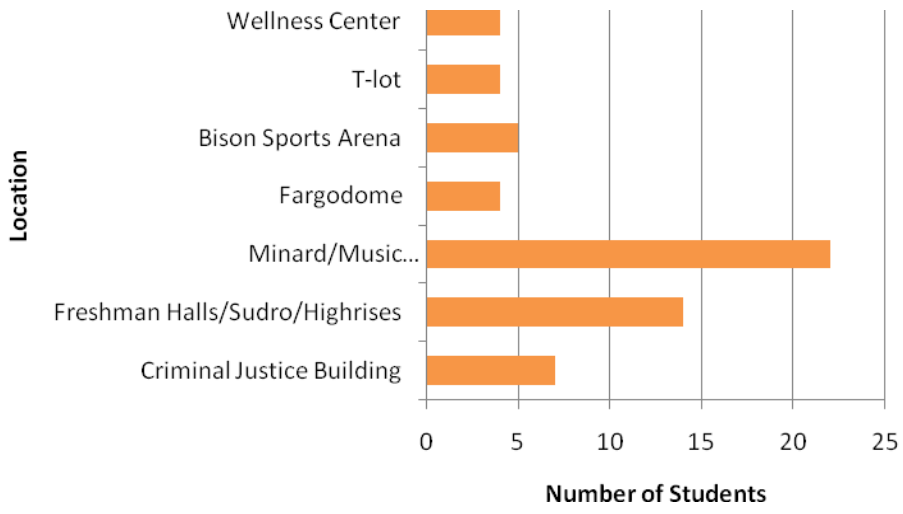

Figure 3.33 Destinations On Campus Too Far to Walk Between (First Wave)

3.7 Current Public Transportation Use

Of the respondents, 79% know that the MAT bus is free; however, only 33% hae ever used the bus.

3.7.1 Students' Already Using MAT

Of the students already using the MAT bus, only 25% have used it as a transportation mode to campus. Other reasons for using the service include getting around campus for 27% and shopping for 19% (Figure 3.34).

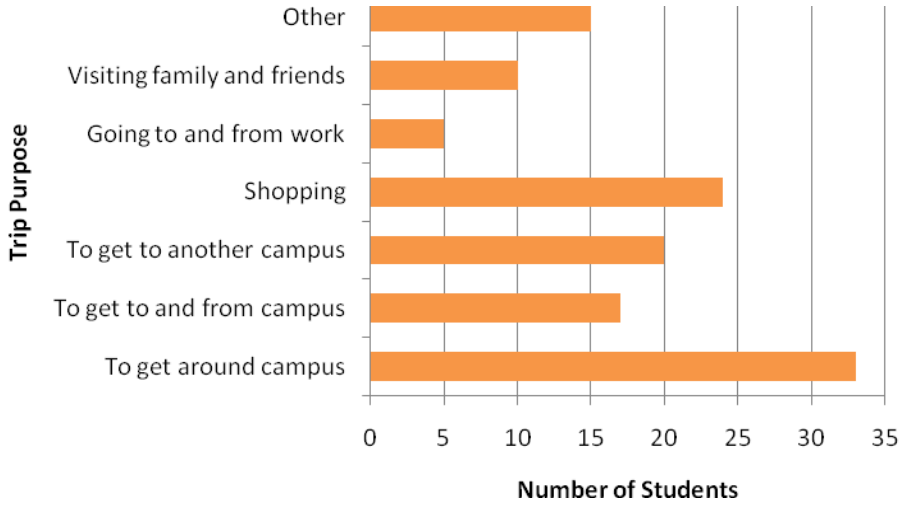

Figure 3.34 First Wave Students' Previous Use of MAT Bus

The overall experience for previous riders varies by category; however, 95% of students rate their experience as neutral or above, and 72% as agree or above (Figure 3.35). To start, bus cleanliness receives the lowest ratings with only 22% strongly agreeing and 39% agreeing. On-time arrival is not rated much higher, with 23% strongly agreeing and 41% in agreement. However, taking the individual where he or she needs to go is the second highest category, with 35% strongly agreeing and 52% in agreement. Finally, ease of use is the highest category with 43% in strong agreement and 45% in agreement. Respondents were also given the opportunity to list and rate other elements to explain their experience. The responses provided include the service being slow, comfortable and convenient, and a lack of bus shelters.

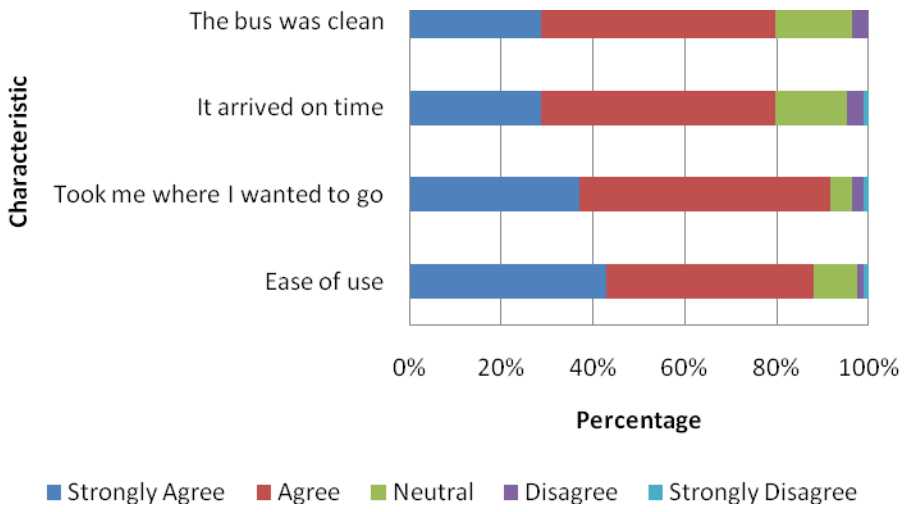

Figure 3.35 First Wave Students' Feelings Toward Previous MAT Use

Further, when asked to rate their agreeableness based on importance related to different features of the MAT service, 32% strongly agree and 39% agree (Figure 3.36). In the area of servicing the FM area 33% strongly agree and 41% agree. The environmentally friendly aspect of using a bus received strong agreement from 23% and 37% of respondents. As for reliability, 27% strongly agree and 51% agree. Thirty one percent of respondents strongly agree that the drivers are informative while 38% agree with that statement. Sixteen percent strongly agree in bus comfort, while 52% agree. The convenience of using the bus is strongly agreed upon by 33% and 45% agree. Believing that riding the bus is less stressful than driving is strongly agreed upon by 28% and 33%. The highest category is that the bus is free, with 77% strongly agreeing and 17% agreeing. When provided another category, student responses include that the bus took too long to go places and that it was easy to use.

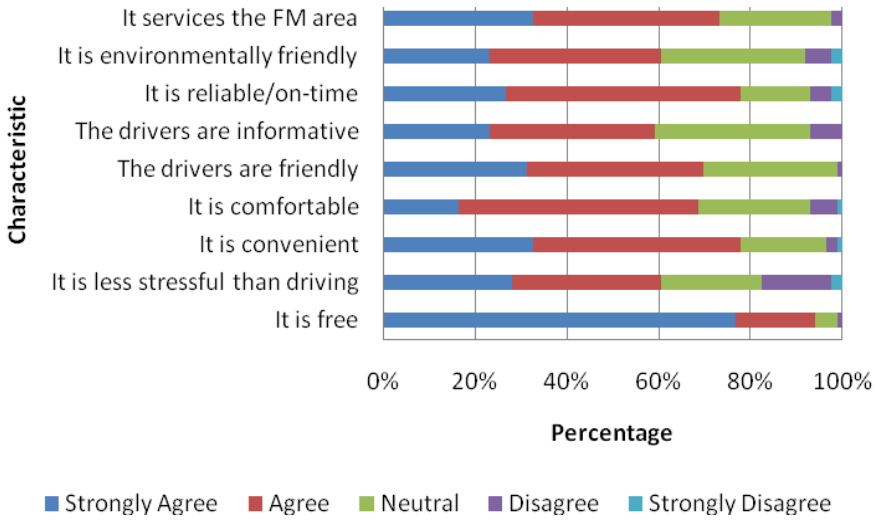

Figure 3.36 MAT Characteristics and Students' Level of Importance (First Wave)

3.7.2 Students' Not Using MAT

Of the remaining 77% of students not already using the MAT service, a high proportion, 86%, either agree or strongly agree with it being their preference to drive, walk, or bike (Figure 3.37). The factor of taking too long is only strongly agreed upon by 13% and agreed upon by 28%. Unreliability has the smallest rating, with only 3% strongly agreeing and 6% agreeing. As for no route where they needed to go, 6% strongly agree and 23% agree. Lack of information is the second largest category, with 13% strongly agreeing and 36% agreeing. Only 2% strongly agree and 8% agree that buses aren't cool. The top category is a preference to drive, walk, or bike with 41% strongly agreeing and 45% agreeing. Other responses provided include a lack of interest in riding, time required to use the service, costs, and bad experiences by friends.

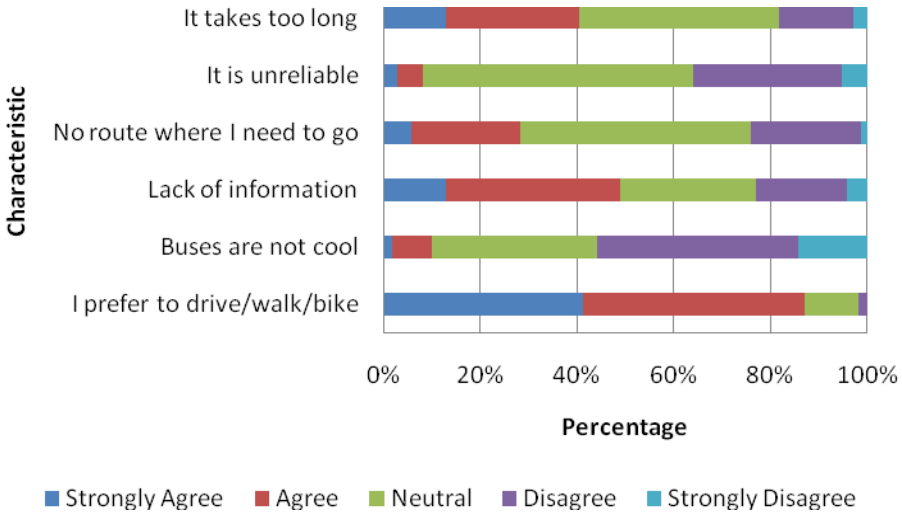

Figure 3.37 Potential Factors Limiting Students Use of MAT Bus (First Wave)

3.7.3 MAT Options

The option of implementing the Guaranteed Ride Home Program to increase students' willingness to ride the MAT generates only 33% in favor, with a majority citing the 'don't know' category at 52% (Figure 3.38).

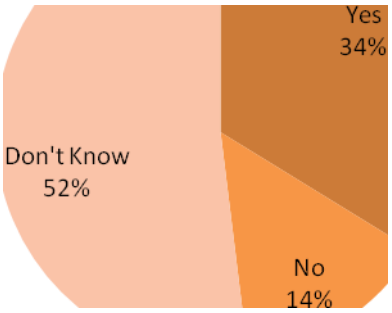

Figure 3.38 Increased Willingness to Use the MAT with the Guaranteed Ride Home Program (First Wave)

As for the wait times if a student were to miss a MAT bus, the top response was to wait 15 minutes by 60% of students, with the next highest of not waiting at 31% (Figure 3.39). For times longer than 30 minutes, there is only one student response for a willingness to wait 45 minutes for the next bus and no responses are given for waiting 60 minutes.

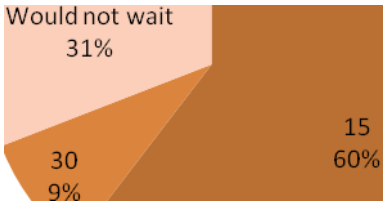

Figure 3.39 Amount of Time a First Wave Student Would Wait for the Next MAT Bus

Charging an activity fee for unlimited use of the MAT bus is overwhelmingly unpopular with 88% of students stating they are not willing to pay. Of the remaining 11% of students willing to pay, there was a variety of stated amounts with none surpassing the others except for above fifty dollars, as there are only two people willing to pay the amount (Figure 3.40).

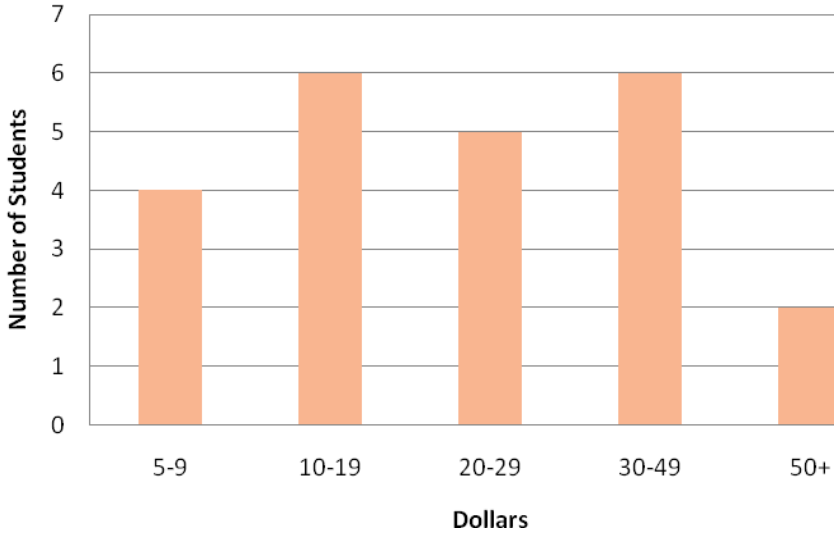

Figure 3.40 Price Willing to Pay for MAT Use (First Wave)

3.7.4 Campus Circulators

Only 42% of the respondents are familiar with the Campus Circulators, while 21% have actually used the service. Additionally, only 4% believe Campus Circulators need more stops added into the route. Potential new service locations include the residence halls, Bison Sports Arena, Political Science/Criminal Justice building, Memorial Union, Askanese Hall, Wellness Center, and Alumni Center. If a student were to use the Campus Circulators and miss the bus, 35% would wait less than 5 minutes followed closely by 32% who would not wait (Figure 3.41).

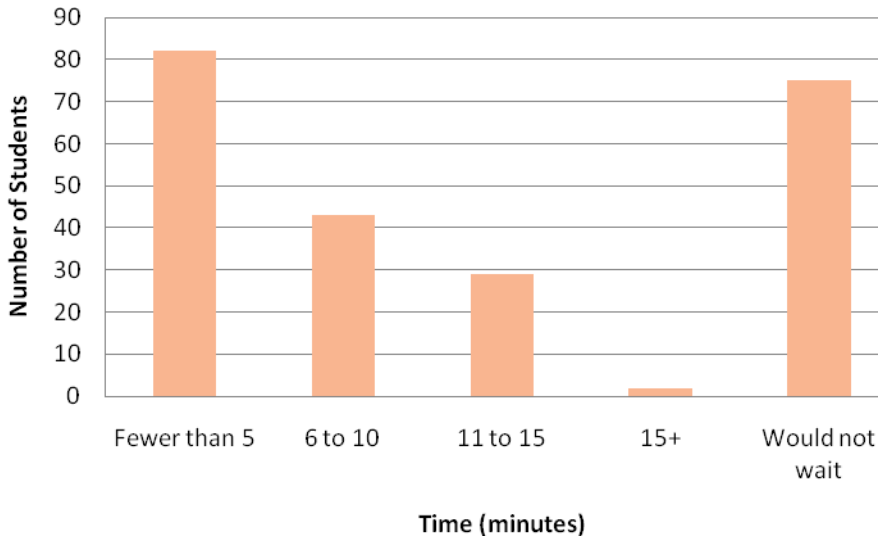

Figure 3.41 Wait Time for Next Campus Circulator (First Wave)

3.7.5 Deuce Use

Currently, 24% of students use the Deuce taxi service in the evening, and of those individuals, 85% are not using the service before 10 pm. Furthermore, 79% state that their use of the Deuce has not decreased their evening use of the MAT service after 9 pm. Finally, only 11% of students have considered using the MAT to go out at night and the Deuce to return home.

3.8 Capital Improvement

At present, only 24% of students feel more bus shelters are necessary for NDSU. The top three locations suggested include at every stop, Minard Hall and the Residence Halls (Figure 3.42). The stops presented include those where more than one student suggest the location.

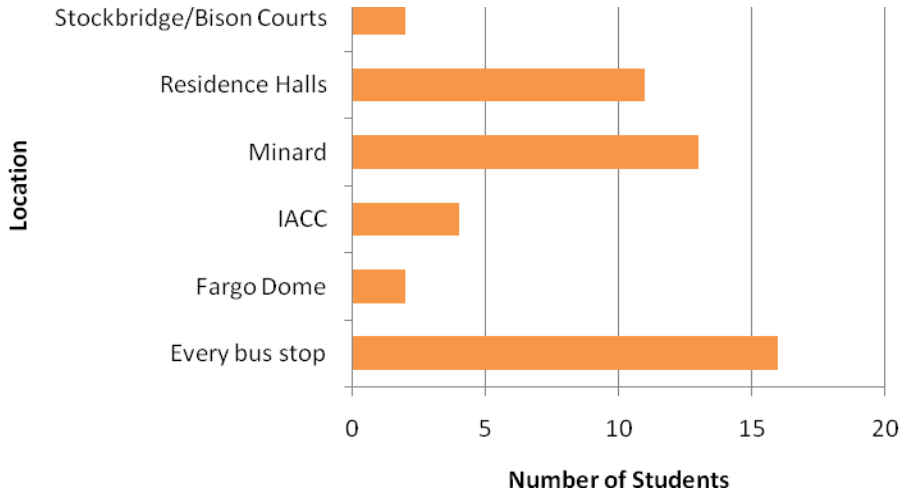

Figure 3.42 Potential Bus Shelter Locations (First Wave)

As for heated bus shelters, only 40% of students are aware of them and of that only 17% reported having used a heated bus shelter. For the students who have used a heated bus shelter, 98% rated their experience at neutral and above (Figure 3.43). Thirty percent of previous users strongly agree and 55% agree that the heated shelter is safe. The benefits of warmth in the shelters is strongly agreed upon by 26% and 51% agreed. Protection from the elements was strongly agreed upon by 36% and agreed upon by 55%. Shelter cleanliness is strongly agreed upon by 25% and 68% strongly agree making it the highest rated category. Finally, the location is strongly agreed upon by 32%, and 59% agreed.

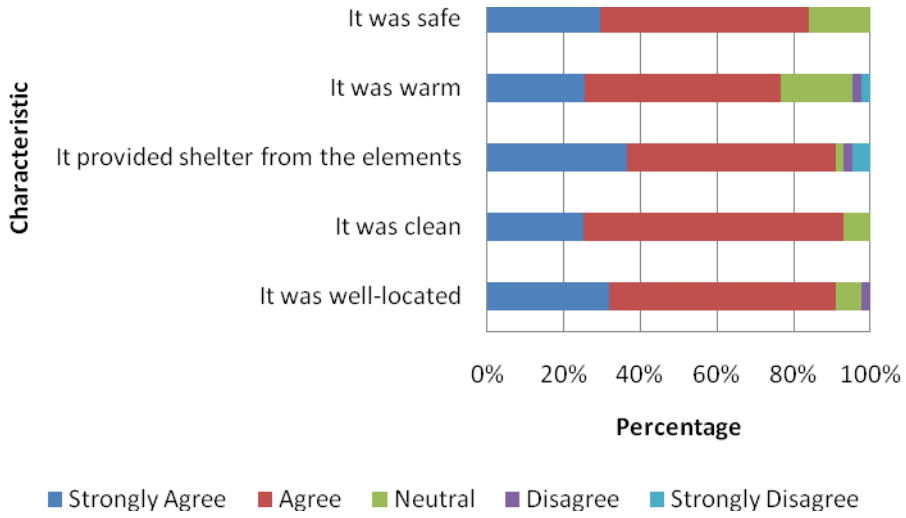

Figure 3.43 Characteristics of Heated Shelter Experience (First Wave)

Increasing the number of heated shelters is favorable to 27% of students. The top response for heated shelter locations is all the bus shelters, with the next level at the residence halls (Figure 3.44).

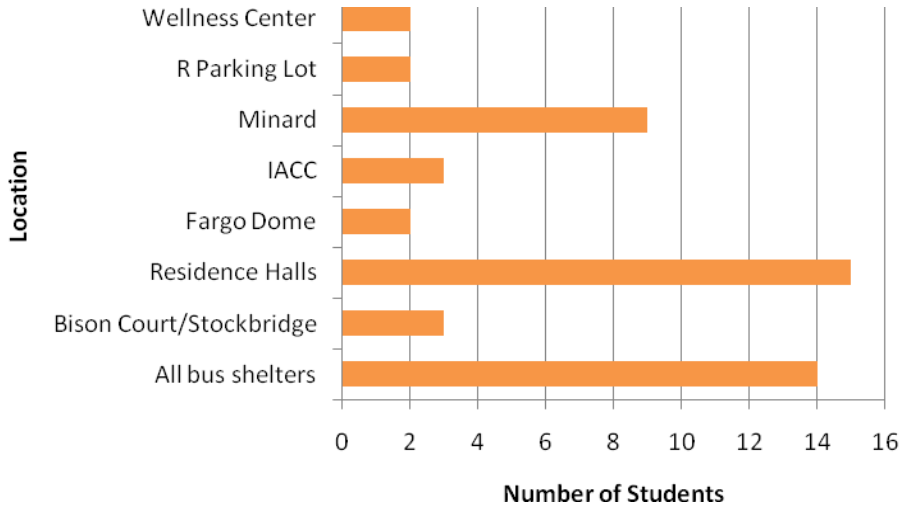

Figure 3.44 Potential Heated Bus Shelter Locations (First Wave)

3.9 Tri-College

While students can take courses at other campus, 53% state they have no intention to do so, while only 8% said yes. The remaining 39% are unsure (Figure 3.45).

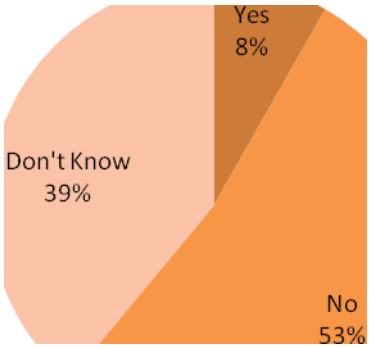

Figure 3.45 First Wave Students' intention to take tri-college classes

For those 8% of respondents planning to take Tri-College classes, 83% state their class would be during day hours, and the remaining 17% of students would be attending an evening class (Figure 3.46).

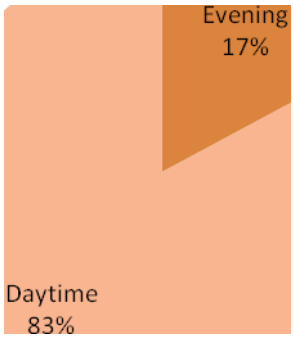

Figure 3.46 Class Times for First Wave Students Taking Tri-College Classes

In addition, of those taking classes, 61% are interested in using the MAT system, with 26% not interested and 13% unsure if they would use the service (Figure 3.47).

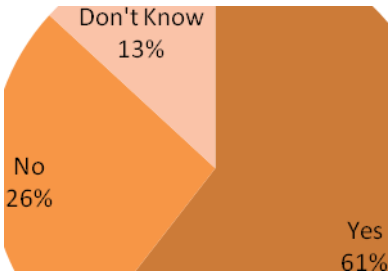

Figure 3.47 Potential MAT Use for Tri-College Class Attendees(First Wave)

3.10 Benefits of Public Transportation

The public transportation benefit of convenience received the largest number of responses at 19%, followed by a three-way tie at 17% each for reduced parking demand, money savings, and reduced traffic congestion (Figure 3.48).

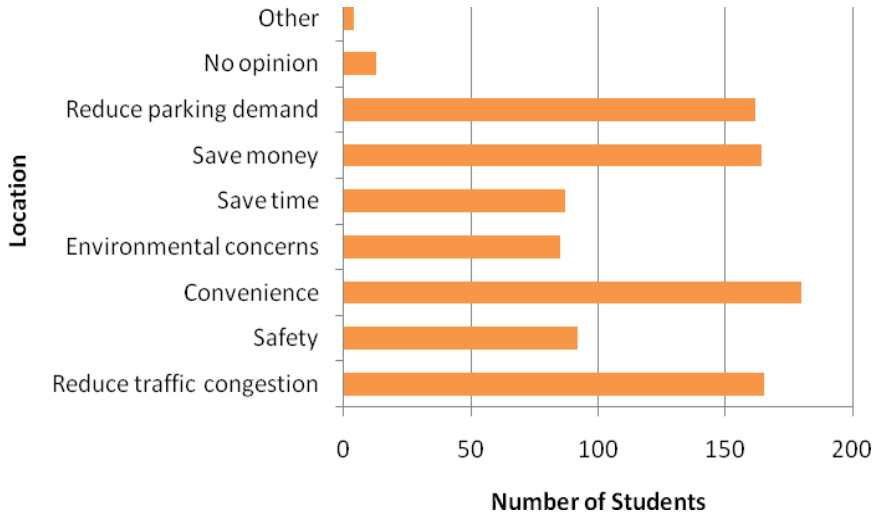

Figure 3.48 First Wave Students Perceived Benefits of Public Transportation

4. SECOND WAVE RESULTS

The second wave of the longitudinal survey conducted during the spring of 2007 collected data from 132 sophomores at NDSU. These students represented approximately 6% of their sophomore class during the spring 2007 academic semester: 2,341 students. The male to female distribution involve 54% female and 46% male, a slight deviation from the total class proportion of 56% male and 44% female. As for age distribution, the majority of respondents, 70%, are twenty years old, followed by 25% at nineteen years of age (Figure 4.1).

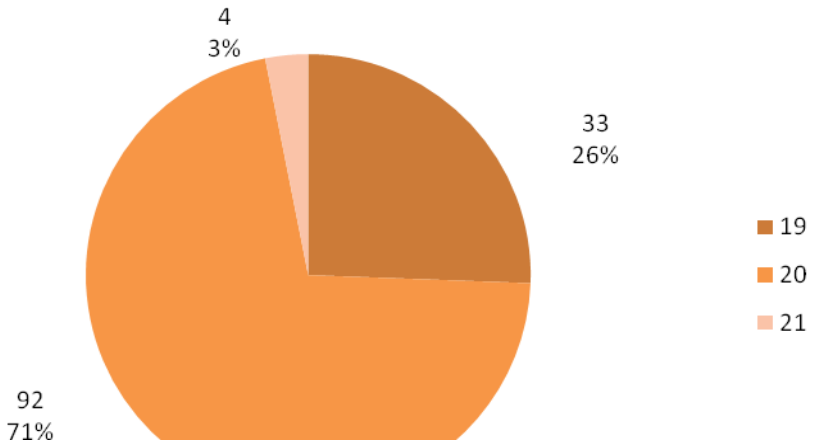

Figure 4.1 Distribution of Second Wave Respondents by Age

4.1 Life Events

4.1.1 Past Six Months Events

Of fourteen possible life events, the event most frequently reported was a change in finances (Figure 4.2). This is followed closely by beginning a new job.

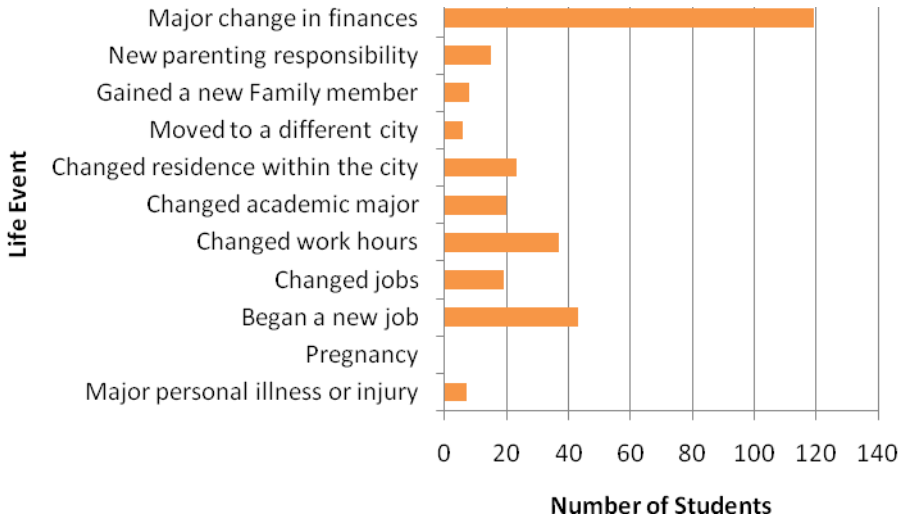

Figure 4.2 Number of Second Wave Students Experiencing Particular Life Events Within the Past Six Months

4.1.2 Motor Vehicle Use During School

The majority of respondents, 89%, report having access to a motor vehicle while attending school. This is an increase of 12% over the freshmen response rate.

4.1.3 Living Situation

Of the respondents, 42% report living on-campus, and the remaining 58% off-campus. This is a substantial change from first wave findings, where 80% of then-freshmen lived on campus. Sixty-five percent report that transportation to and from campus is a factor in the housing decision.

4.1.4 On-Campus Students

Of the 42% of students who elect to live on campus, 78% report most frequently leaving campus for general shopping purposes (Figure 4.3). Visiting family and friends, 49%, and entertainment, 61%, are also highly reported.

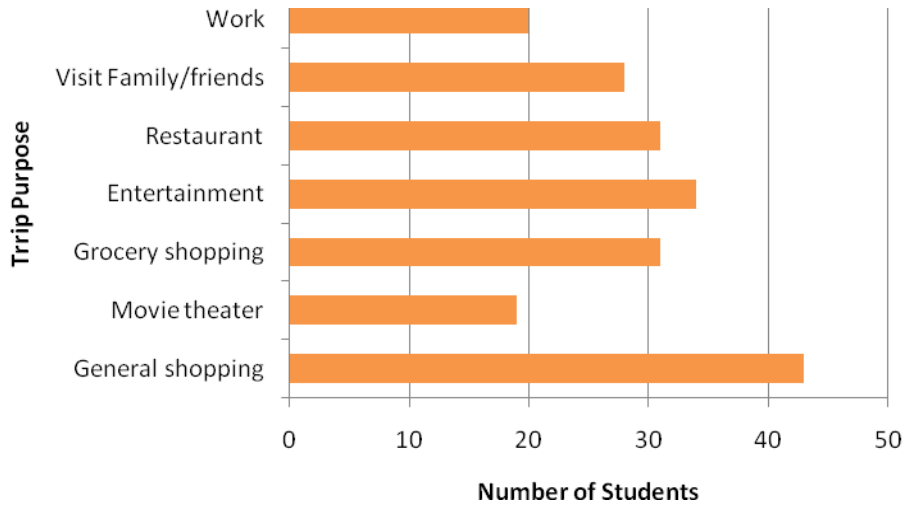

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Figure 4.3 Reasons Second Wave Students Residing on Campus Most Frequently Leave

4.2 Off-Campus Students

4.2.1 Housing Location

Of the 58% of students choosing to reside off-campus, the most reported area is North Fargo at 58% (Figure 4.4). South Fargo is the second most reported area at 26%.

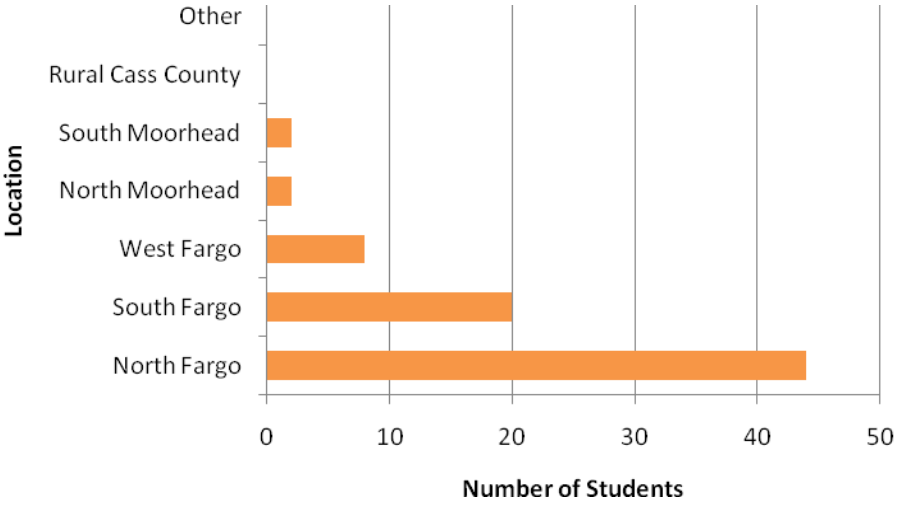

Figure 4.4 Second Wave Student Housing Locations

The three most reported distances to students' residence from campus ware 33% less than a quarter of a mile from campus, 25% over five miles, and 21% between two and five miles (Figure 4.5). Compared with first wave results, significantly more students live more than five miles from campus as sophomores than as freshmen.

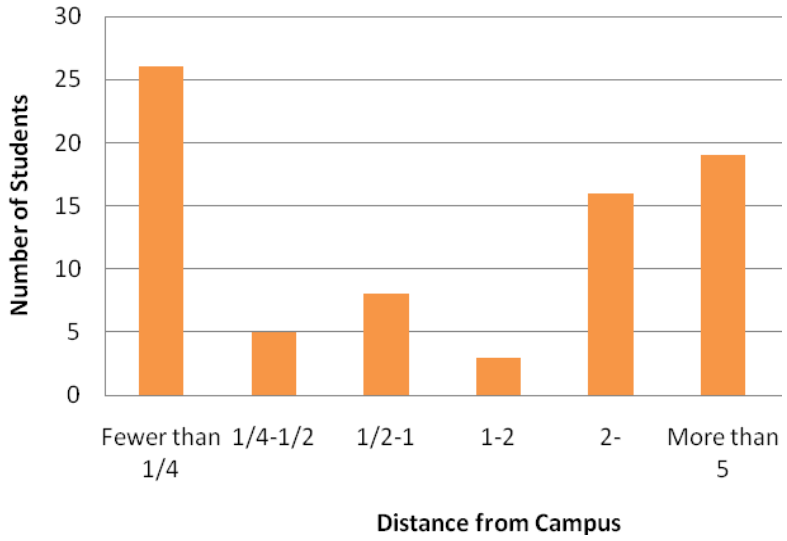

Figure 4.5 One-Way Distance Between Second Wave Students' Residence and NDSU

4.2.2 Times Frequently on Campus

Eighty percent of off-campus students are on campus between 8 am and 4 pm (Figure 4.6). The peak time frame occurs between 8 am and 4 pm, when 57% of all respondents are on campus.

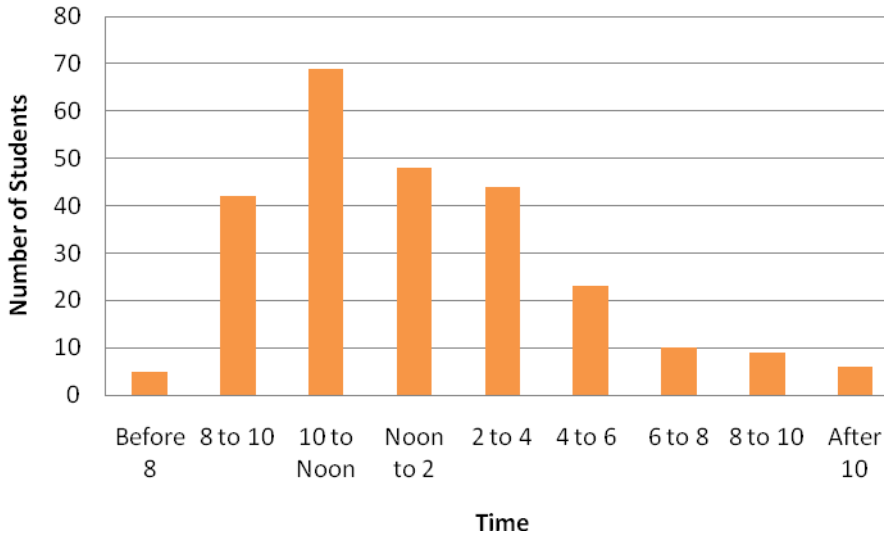

Figure 4.6 Periods in Which Second Wave Off-Campus Students are Most Frequently on Campus

4.2.3 Travel to Campus

Ninety-five percent of students state when traveling to campus, they are coming from their homes, while the remaining five percent is divided between work and shopping. Additionally, 49% of students make two one-way trips and 19% make four one-way trips,with the remaining 5% scattered between one and six trips per day (Figure 4.7).

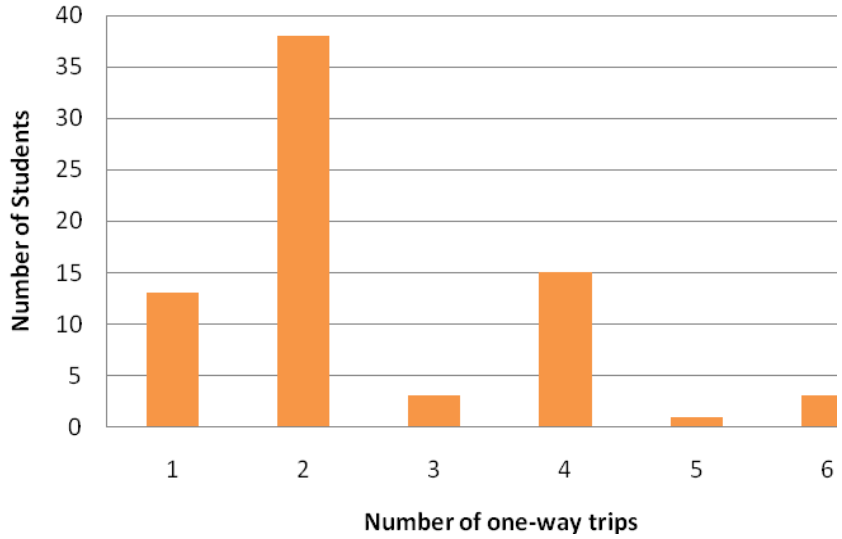

Figure 4.7 Second Wave Students' One-Way Trips Between Home and Campus

The primary mode of travel is personal automobile, which was reported by 61% of respondents. Walking is the second most reported mode at 40% (Figure 4.8).

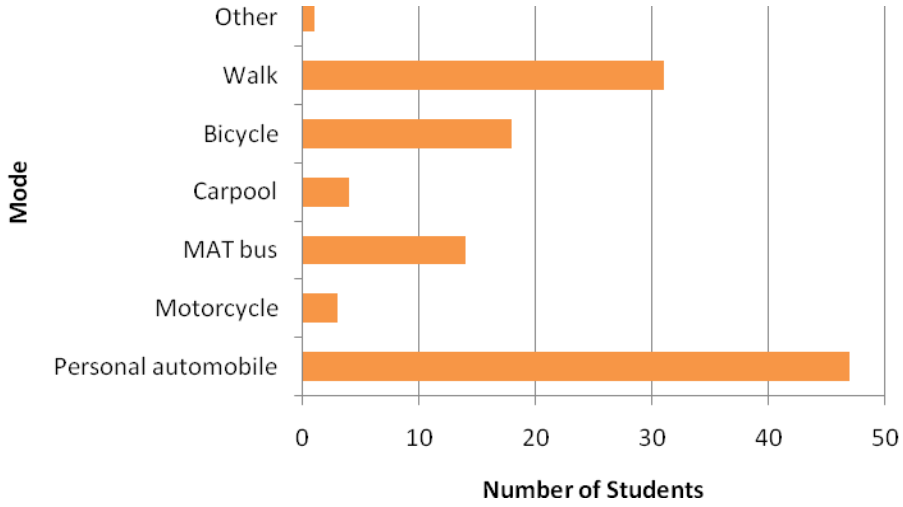

Figure 4.8 Modes of Transportation Used by Students to Get to Campus (Second Wave)

Of students using personal automobiles, 89% have a travel time of less than 19 minutes to campus (Figure 4.9). Of that 89%, 40% have times of nine minutes or less, and 49% have times of ten to nineteen minutes.

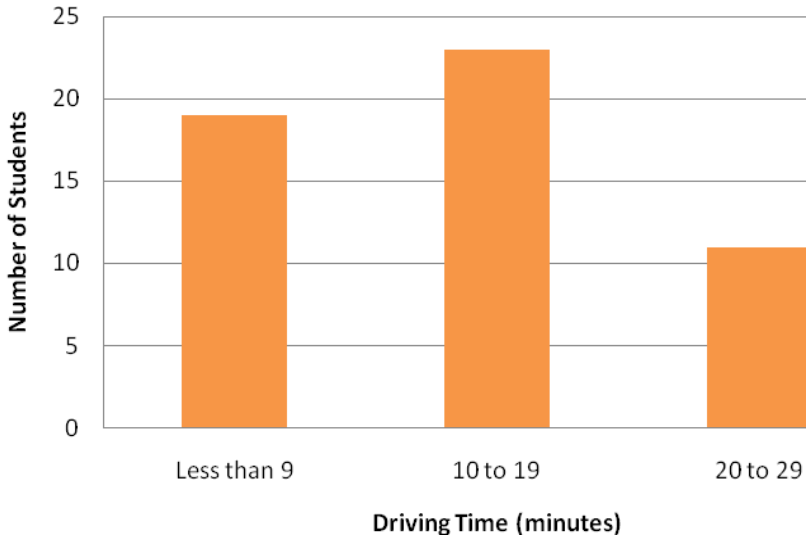

Figure 4.9 Travel Time for Second Wave Students Using Personal Automobile's to Get to Campus

The top response regarding acceptable trip times for a bus ride between home and campus is 10-15 minutes at 35% (Figure 4.10). The next highest response is 34% for less than nine. Both of these response rates are higher than in the first wave. This may be due to the increased distance between students' residence and class.

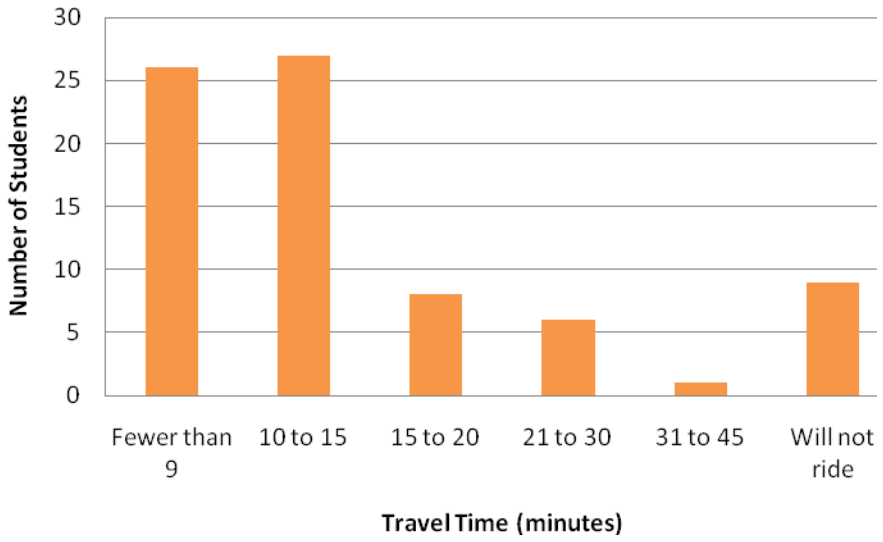

Figure 4.10 Acceptable Trip Time From Home to Campus by Bus (Second Wave)

With the largest segment of students not willing to ride, the factors in mode selection become increasingly important to understand. When asked to rate the categories of time, parking availability, weather, cost of parking, cost of the vehicle, and convenience, 49% rate them as very important, while 28% rate them as important (Figure 4.11). The time factor in mode selection is very important to 58% of students and important to 33%. Parking availability is very important to 42% and important to another 35%. Weather receives the lowest emphasis, with only 32% stating it is very important and 27% important. The cost to park receives 45% for very important and 26% for important. Similarly, the cost of a vehicle has 51% in strong agreement and 19% in agreement. Convenience is rated the highest with 65% stating that it is very important and 29% for important.

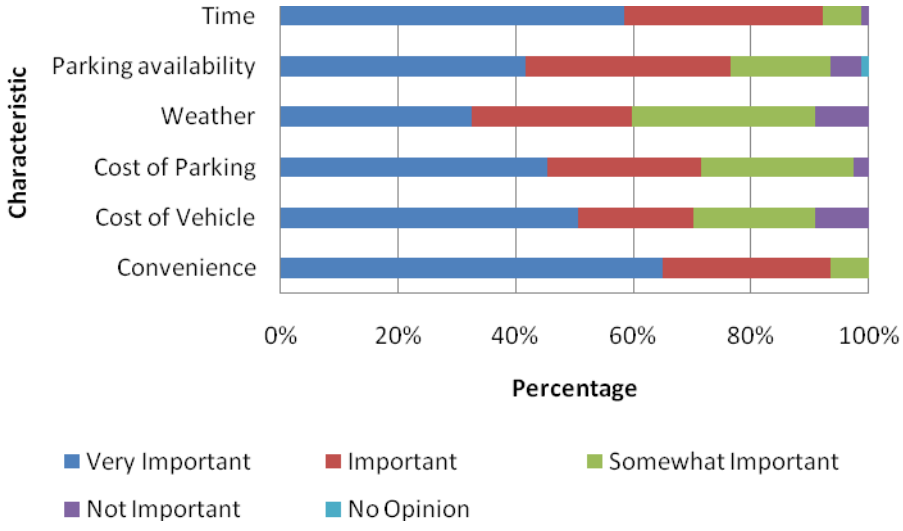

Figure 4.11 Factors Affecting Mode of Transportation Choices (Second Wave)

4.3 Campus Parking

4.3.1 Current Parking Permit

Currently, 58% of the students state they have parking permits. Of those students with a parking permit, only 26% occasionally park on the street. For the students with parking permits, the primary parking area is HR-lot at 48% (Figure 4.12).

Figure 4.12 Students Parking Permit Locations (Second Wave)

Of students holding parking permits, 39% rate the convenience as fair and 17% as good (Figure 4.13).

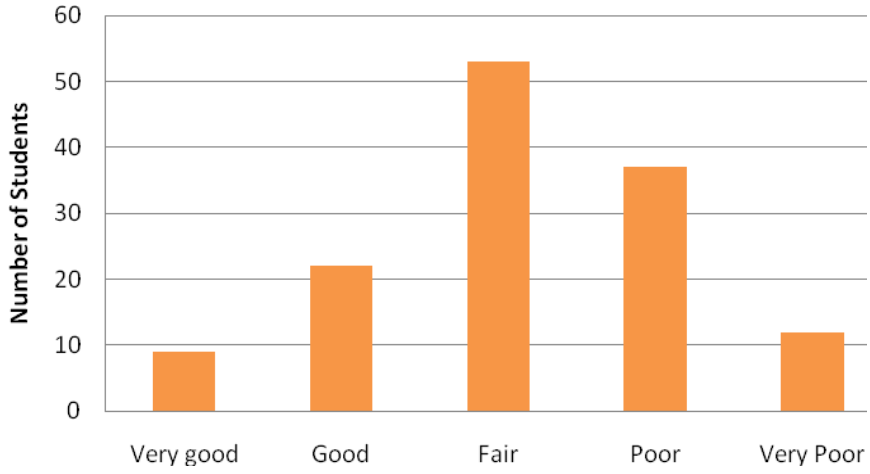

Figure 4.13 Rating Parking Permits Based on Convenience (Second Wave)

Parking permit affordability has 42% of students ranking it as fair with another 5% rating it as poor (Figure 4.14).

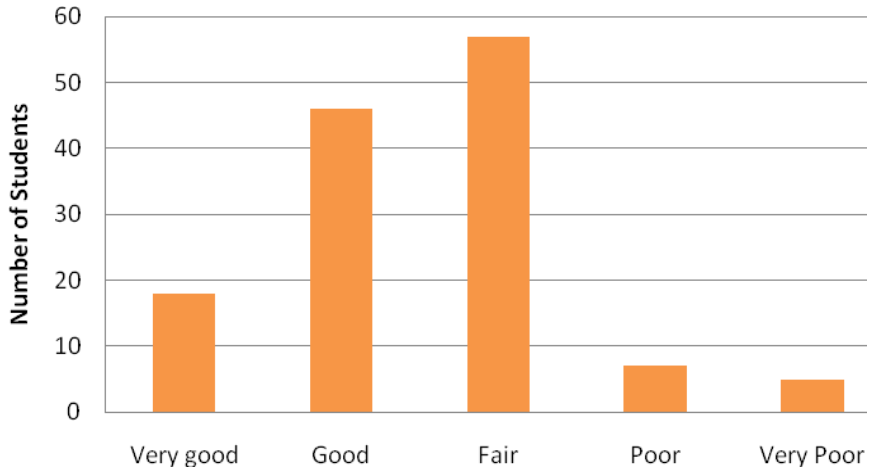

Figure 4.14 Rating Parking Permits Based on Affordability (Second Wave)

As for the implementation of off-campus parking lots and adjacent bus routes, 81% of students would wait 15 minutes for a bus; however, only 17% of students would wait 30 minutes for the next bus.

4.4 Walking

Sixty-four percent of students state that the maximum distance they would be willing to walk when the temperature is below freezing is less than a quarter of a mile. Ninety-four percent state the distance they would walk is less than half a mile (Figure 4.15). On days when the temperature is above freezing, students state almost evenly that walking anywhere from a mile to a quarter of a mile is an acceptable distance.

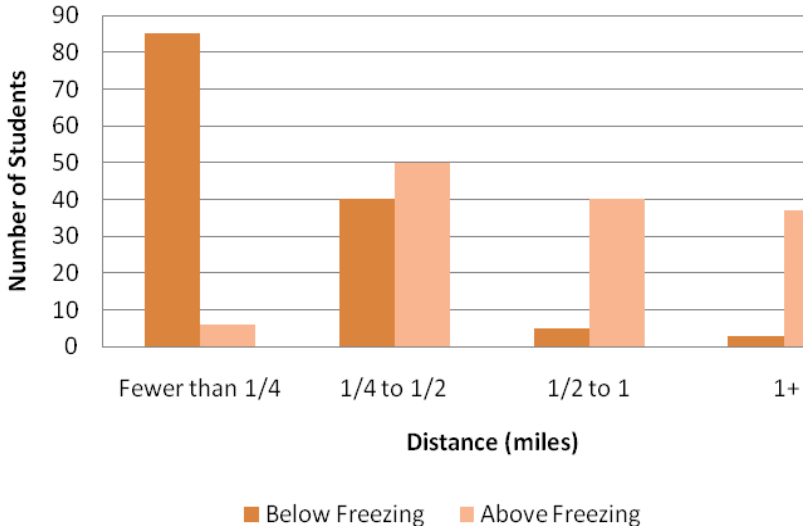

Figure 4.15 Reasonable Walking Distance for Second Wave Students

4.5 Current Public Transportation Use

The number of students that use public transportation rose from 33% of freshman to 45% of sophomores.

4.5.1 Students Already Using MAT

Of the students already using the MAT bus, only 30% have used it as a transportation mode to campus. Other reasons for using the service include getting around campus for 41% and shopping for 21% (Figure 4.16).

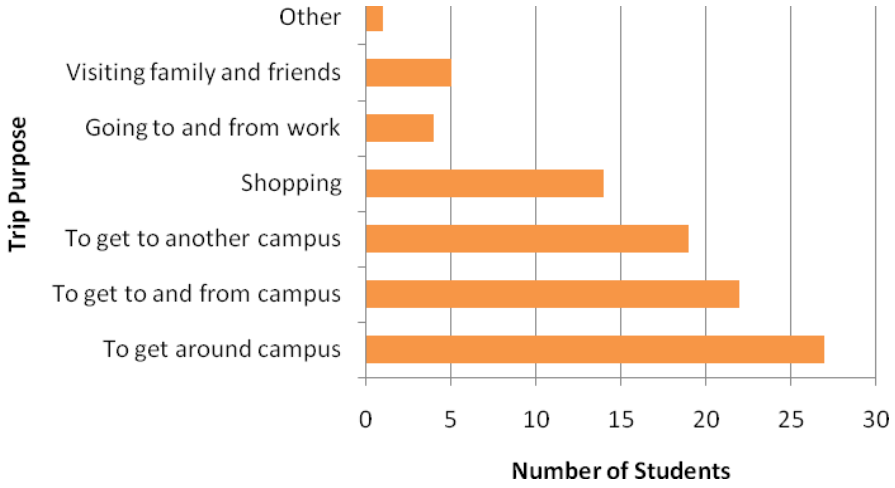

Figure 4.16 Second Wave Students' Previous Use of MAT Bus

The overall experience for previous riders varied by category; however, 100% of students rate their experience as neutral or above, and 87% as agree or above (Figure 4.17). To start, bus cleanliness receives the lowest ratings, with only 41% strongly agreeing and 41% agreeing. On-time arrival is not rated much higher, with 32% strongly agreeing and 46% in agreement. However, taking the individual where he or she needs to go is the highest category with 49% strongly agreeing and 32% in agreement. Finally, ease of use is the second highest category with 46% in strong agreement and 41% in agreement. Respondents were also given the opportunity to list and rate other elements to explain their experiences. The responses include the service being slow, comfortable and convenient, and a lack of bus shelters.

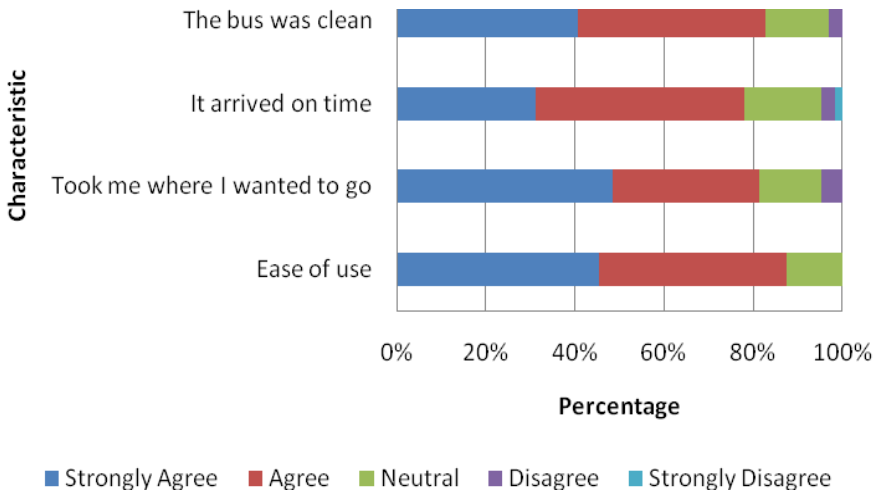

Figure 4.17 Second Wave Students' Feelings Toward Previous MAT Use

Further, when asked to rate their agreeableness based on importance related to different features of the MAT service, 34% strongly agree and 38% agree (Figure 4.18). In the area of servicing the FM area, 29% strongly agree and 52% agree. The environmentally friendly aspect of using a bus receives strong agreement from 24% and 48% of respondents. As for reliability, 30% strongly agree and 44% agree. Informative drivers is strongly agreed upon by 19% and agreed upon by 37% of respondents. Twenty-two percent strongly agreed in bus comfort while 41% agreed. The convenience of using the bus is strongly agreed upon by 35% and 41% agreed. Believing that riding the bus is less stressful than driving is strongly agreed upon by 29% and 27%. The highest category is that the bus is free with 89% strongly agreeing and 8% agreeing. When provided another category, student responses include that the bus takes too long to go places and that it is easy to use.

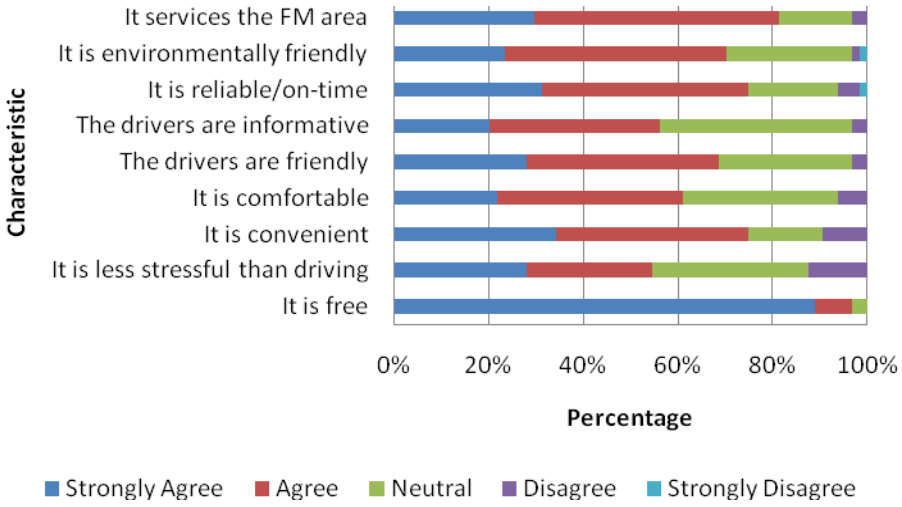

Figure 4.18 MAT Characteristics and Second Wave Students' Level of Importance

4.5.2 Students Not Using MAT

Of the remaining 55% of students not already using the MAT service, a high proportion, 89%, either agree or strongly agree with it being their preference to drive, walk, or bike (Figure 4.19). The factor of taking too long is only strongly agreed upon by 16% and agreed upon by 32%. Unreliability has the smallest rating, with only 3% strongly agreeing and 15% agreeing. As for no route where they needed to go, 3% strongly agree and 21% agree. Lack of information is the third largest category, with 12% strongly agreeing and 34% agreeing. Only 1% strongly agreeand 9% agree that buses aren't 'cool'. The top category is a preference to drive, walk, or bike, with 45% strongly agreeing and 45% agreeing. Other reasons provided for not riding include a lack of interest in riding, time required to use the service, costs, and bad experiences by friends.

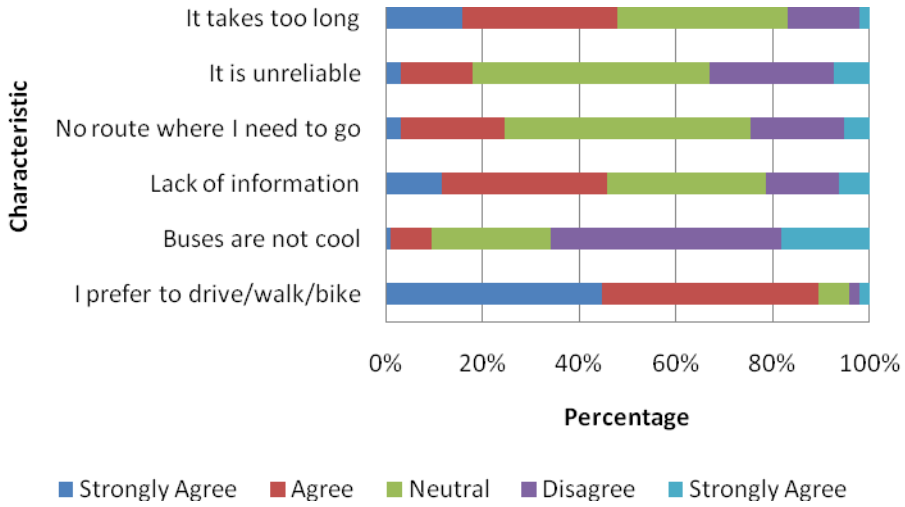

Figure 4.19 Potential Factors Limiting Second Wave Student Use of MAT Bus

4.5.3 MAT Options

The option of implementing the Guaranteed Ride Home Program to increase students' willingness to ride the MAT generate only 39% in favor, with a majority citing the 'don't know' category at 46% (Figure 4.20).

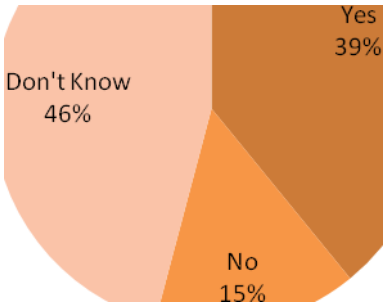

Figure 4.20 Increased Willingness to Use the MAT with the Guaranteed Ride Home Program (Second Wave)

As for the wait times if a student were to miss a MAT bus, the top response is to wait 15 minutes by 65% of students, with the next highest of not waiting at 30% (Figure 4.21). No responses are given for wait times longer than thirty minutes.

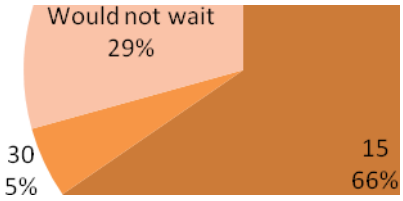

Figure 4.21 Amount of Time a Student Would Wait for the Next MAT Bus (Second Wave)

4.5.4 Campus Circulators

Only 58% of the respondents are familiar with the Campus Circulators while 33% have actually used the service. Additionally, only 3% believe Campus Circulators need more stops added into the route. Potential new service locations include the residence halls, Bison Sports Arena, Political Science/Criminal Justice building, Memorial Union, Askanese Hall, Wellness Center, and Alumni Center. If a student were to use the Campus Circulators and miss the bus, 35% would wait less than five minutes, followed closely by 33% who would not wait (Figure 4.22).

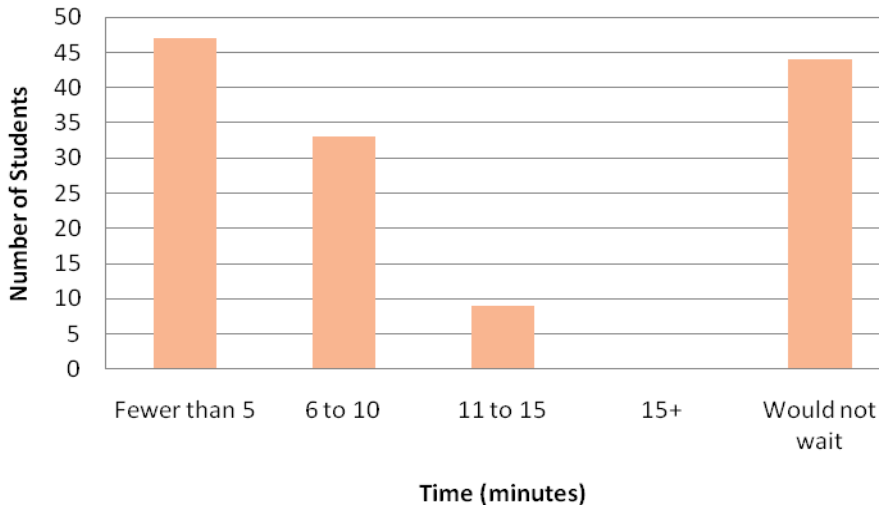

Figure 4.22 Wait Time for Next Campus Circulator (Second Wave)

4.5.5 Deuce Use

Currently, 25% of students use the Deuce taxi service in the evening, and of those individuals, 88% are not using the service before 10 pm. Furthermore, 79% state that their use of the Deuce has not decreased their evening use of the MAT service after 9 pm. Finally, only 15% of students have considered using the MAT to go out at night and the Deuce to return home.

4.6 Tri-College

While students can take courses at other campus, 62% state they have no intention to do so, while only 9% said yes, with the remaining 29% unsure (Figure 4.23).

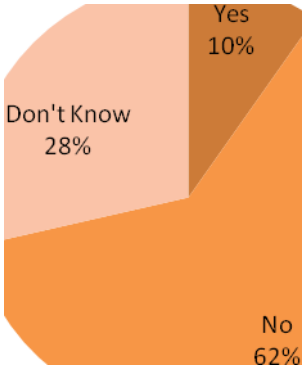

Figure 4.23 Second Wave Students' Intention to Take Tri-College Classes

Of the 9% of respondents planning to take a class, 71% state their class would be during day hours, and the remaining 29% of students would be attending an evening class (Figure 4.24).

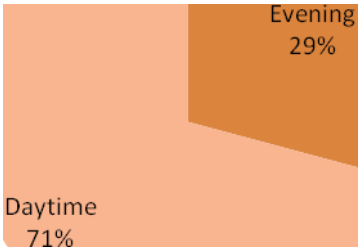

Figure 4.24 Class Times for Second Wave Students Taking Tri-College Classes

In addition, for those taking classes, 39% are interested in using the MAT system, with 17% not interested and 44% unsure if they would use the service (Figure 4.25).

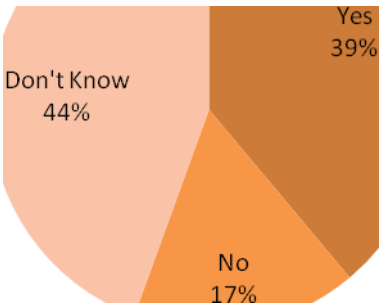

Figure 4.25 Potential MAT Use for Tri-College Class Attendees (Second Wave)

5. ANALYSIS

To rigorously investigate the ridership behavior of first and second year NDSU students, two statistical tools, binary probit modeling and Markov chains, were employed. This is the first time analyses of NDSU campus transit data have been conducted, as in previous years, study concluded with the presentation of descriptive statistics. This study continues by analyzing the role of select variables on first-year transit ridership using a binary probit model.

5.1 First Year Ridership

A number of factors may impact an individual's travel making decisions, including selection of mode. Factors that influence first-year university students include location of residence, vehicle access, and previous experience with transit among others. To formally investigate the role of these and other variables, ridership is modeled as a binary, yes or no, decision. A summary of the method used to estimate the impact of these variables on ridership, the binary probit method, is presented followed by the results of the analysis.

Binary dependent variables may be modeled in a number of ways including the probit model, which relies on the cumulative normal probability distribution. The binary choice model for individual is

$$y_i^* = x_i'\beta + \varepsilon_i$$

where x_i are the attributes of individual I, β model parameters, and ε_i the error term. Dependent variable, y, in our specific case transit ridership, is observed only if

$$y_i = 1 \text{ if } y_i^* > 0$$
$$= 0 \quad ow$$

For the probit model, the error term is modeled using the standard normal distribution

$$\Phi(x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-t^2}{2}\right) dt$$

(as opposed to the logit model, which results when the logistic distribution is employed). The model's goodness-of-fit is evaluated using McFadden's Likelihood Ratio Index (LRI), which is analogous to the R^2, is calculated by

$$R_M^2 = 1 - \left[\frac{lnL}{lnL_o}\right]$$

The findings of the analysis are presented in Table 3. A strong negative relationship between vehicle access and bus ridership is found as expected. However, a surprising positive relationship between transit use when traveling and during the students' freshman year is apparent. This may be sign of a willingness to use transit on an occasional or experimental basis.

A significant negative relationship between on-campus residence and ridership is also apparent. This might be explained by a tendency by first year, on-campus students to walk to classes and use personal automobiles for long-distance trips. A significant positive relationship between use of transit by family and friends is also found.
Gender is not found to be significant in determining ridership. This is contrary to past years where ridership rates varied significantly by sex. However, this finding supports the movement to a stratified survey where selection to participate is mitigated to some degree.

Student's residence distance from campus, previous use of transit, and years of school bus ridership also did not have significant impact on freshman bus ridership. One variable commonly found in discrete choice decision models, income, was not included, as many students have significant sources of funds outside of earned income including scholarships, grants, and gifts. The LRI for the model is .10.

Table 5.1 Results of Binary Probit Analysis

Intercept	0.05	
Gender	0.18	
Vehicle Access	-0.83	**
On-Campus Residence	-0.51	*
School Bus (Years)	0.03	
Distance to Campus	-0.05	
Previous Use	-0.18	
Use when Traveling	0.41	**
Friends & Family Use	0.3	*

* Significant at 10% level ** Significant at 5% level

5.2 Changing Ridership

With longitudinal data, individual changes in attitudes and previous can be determined. In the case of transit, the use of longitudinal data allows one to track individual changes in ridership instead of sample averages. This information can be used to estimate a transition matrix that presents changes between occur between two states: riders and non-riders, over the course of a year (Figure 5.1). Along these lines, second year riders can be grouped into one of four classes: new riders, current riders who did not rider in the previous year; former riders, former riders who did not ride in the second year; retained riders, individuals who rode the bus during each year; and non-riders, those who did not ride in either year.

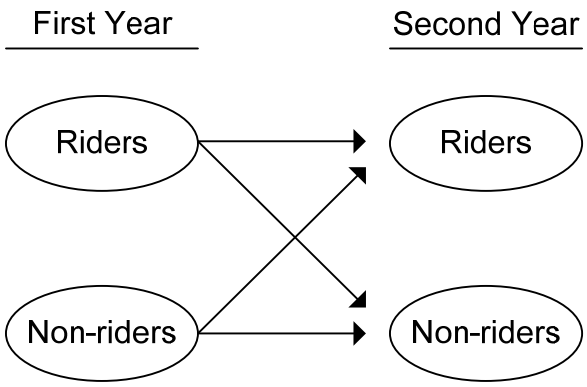

Figure 5.1 Student Ridership States

This information can be valuable to marketing and planning efforts. However, a special caveat for university transit is necessary. As university students often experience dramatic changes in circumstances from year to year, there may be commensurate swings in travel behavior. This case is certainly true for North Dakota State University students who are generally required to live on-campus if they are under the age of 19. Students travel behavior over time are also likely influenced by the Tri-College and Downtown campuses.

The Markov transition matrix for NDSU freshmen and sophomores is presented in Table 4. Overall reported ridership increased from 33% to 45% between students' first and second years at NDSU. Of those students who responded to the first and second waves, 48% of the students who rode the bus as freshman also rode as sophomores, and 45 % of those who didn't ride as freshman rode their second year.

Table 5.2 Student Ridership Transition Matrix

	Sophomores	
Freshmen	Rider	Non-rider
Rider	0.48	0.52
Non-Rider	0.45	0.55

At first glance, it may be surprising to see large numbers of sophomores not riding the bus when they had the year before. However, this may be explained by changes in circumstances, including moving off-campus. This hypothesis is also supported by the binary probit analysis where there is an insignificant relationship between previous transit riders and ridership by freshmen.

The transition matrix provides a snapshot of information for the 2005 NDSU freshmen cohort. Many factors determine changes in ridership behavior which are not accounted for by the method. The environment in which students are making their travel making decisions is changing, as are the students themselves.

Given NDSU policy requiring students to live on campus, it will be interesting to see changes in ridership that occur between students' sophomore and senior years as identified by comparing the results of the second and third, final wave of the study. Tremendous development, including new apartment units and commercial businesses near the university's campus, is occurring and will likely impact housing and transit ridership decisions between students' second and fourth year at NDSU. This, combined with the growth of the university's downtown campus and commensurate increase in transit service between the main and downtown campuses, is expected to have a

significant, positive effect on student ridership.

6. FINDINGS AND CONCLUSIONS

In this paper, the design and initial findings of a longitudinal study intended to investigate the impact of changing attitudes and behaviors on public transportation ridership by North Dakota State University students are presented. The objective is to improve upon previous survey efforts with more rigorous sampling and to make available additional methods of analysis by employing a longitudinal framework where the same students would be surveyed throughout their undergraduate careers. More efficient sampling has the added benefit of reducing survey costs.

Previous campus transit surveys at North Dakota State University, Concordia College, and Minnesota State University, Moorhead, generated descriptive statistics about students' attitudes and behaviors with regards to transit. However, fluctuations in reported ridership led to questions about the response bias of the surveys. These surveys invited all university students to participate, which led to fluctuations in response rates and possible impacts on statistical quality due to selection to participate. To address this issue, a new survey using a stratified sample was employed.

At the same time, the survey method transitioned to a longitudinal survey. This provided the ability to investigate changes in individual as opposed to aggregate data. The cohort of interest being students who matriculated at North Dakota State University in fall 2005.

6.1 Findings

Vehicle access, on-campus residence, previous use of transit when traveling, and use of transit by family and friends all have a significant impact on ridership for first year students. All have a positive influence with the exception of on-campus residences. This may be explained by a tendency by first-year, on-campus students to walk to classes and use personal automobiles for long-distance trips. Gender, student's residence distance from campus, previous use of transit, and years of school bus ridership do not have a significant impact on bus ridership.

The study finds that ridership increases from 33% of respondents during their freshman year to 45% of respondents during their sophomore years. Only 48% of freshmen who ride the bus also ride as sophomores. However, 45% who did not ride during their first year rode in their second.

6.2 Conclusions

The results of the analysis of the first two waves of the project demonstrate the advantages of employing more rigorous sampling. The sample size during the first two waves of the survey is a fraction of the size of those conducted previously while still producing consistent results. At the same time, data collected in the previous studies do provide some of the information needed to determine minimum sample size.

The longitudinal framework provides an opportunity to investigate relationships that wouldn't otherwise be possible including calculation of the transition matrix for first and second year students. The data set will prove even more valuable after conducting the next and final wave of the study.

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