Reducing Our Carbon Footprint through Ridesharing

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Research Experiences for Teachers

The University of North Texas

National Science Foundation

Grant Number NSF-1132585 and NSF-1017926

Abstract

The focus of this research project was to analyze and collect travel trajectories to calculate carbon footprints under different travel modes and identify ways to reduce it. We collected trajectory data using GPS from RET participants and translated it into energy consumption to determine if shared ride modes were available and the corresponding amount of reduced carbon footprints. We also researched issues associated with ridesharing such as coordination of routes, safety concerns, time costs, and social discomfort. Ridesharing is a possible solution to help reduce increasing amount of carbon emissions in our growing communities.

Introduction

Ridesharing is a possible solution for many of the problems our modern society and world is facing. With the availability of low cost GPS devices, smartphones and wireless networks, large-scale real-time ridesharing possibilities surmount. While our society and the world struggles with congestion, pollution, energy efficiencies and intensive economies, many private and public vehicles are still barely occupied. If the human population began to better utilize rideshare opportunities using the technologies available, we could substantially reduce the carbon footprint and therefore slow the depletion of the world resources. Several factors are thought to impede the use of ridesharing programs. Included in this list would be the lack of trust amongst co-passengers, loss of personal flexibility, safety risks, and the availability of dynamic route matching algorithms that minimize queues and total travel time, etc (Chaube, Kavanaugh & Perez-Quinones, 2010; Resnick, 2003). In this paper, some factors that impede ridesharing will be investigated. It is hypothesized that if major inroads were made with systems that built trust amongst drivers and riders, improve ways of increasing flexibility for those choosing to rideshare and reduce safety risks, then more people would rideshare and it could be a remedy for our energy dependence.

Literature Review

In a research article by Chaube, Kavanaugh, and Perez-Quinones (2010), trust was identified as the most important factor in determining whether people would give or take rides from others. The authors referred to work by Mayer and Davis in defining trust as “the willingness of a party to be vulnerable to the actions of another party based on expectations that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party”. People feel a certain amount of discomfort when trust is not at a high level during social interactions. Chaube et al. also refer to work by Cook and Wall who defined trust in terms of confidence. Cook and Wall says trust is “the extent to which one is willing to ascribe good intentions to and have confidence in the words and actions of other people”. A “friend of a friend” is considered to be more trustworthy than a stranger and a cousin would be considered less trustworthy than a brother or sister. In an effort to mitigate some of the trust issues several ridesharing applications have been developed. Goloco, NuRide, and ERideShare to name a few, have a feature which builds a profile of the drivers and passengers and include a rating system that is aimed at improving the credibility of both and therefore making people feel more comfortable ridesharing. Trust could also be tied to one’s ability to be comfortable with other factors such as a person’s legal driving habits or whether the person was a smoker.

Convenience was also noted in the article by Chaube et al. as being a big contributor as to a person’s openness and willingness to rideshare. About 54% of the rideshare participants said that finding and setting up rides was a reason for not ridesharing. Convenience and flexibility go hand in hand. Chaube et al. findings suggest that the inability to make last minute modifications to ones travel plans, getting to the rendezvous location, and making either too few or too many stops were also considered convenience issues. Next, in support of the importance that the social aspects have on the decision to rideshare or not, a research article by Resnick (2003) explores instant rideshare aspects and the use of technology to assist with making ridesharing more appealing. Resnick (2003) implies that current technology can be used to increase security, trust, flexibility, and concerns associated with routes. It was noted that infrastructure could be developed by cell phone companies that could provide pickup and drop-off data through the triangulation of cell phone towers or GPS and passing any data on to provide emergency responses. Real time route matching needs could also be mitigated by developing applications that would take into account the dynamic needs involved in ridesharing. This is extremely important because the window of opportunity tends to be on the order of seconds before the driver will pass the pickup spot. Also, one way of incorporating safety into the design could be to have an authentication based system that had a password or PIN code that was entered upon pickup and drop-off. Both driver and passenger could enter their respective codes at the beginning and end of the trip and the authorities called automatically if either person did not reach their destination. The instant ridesharing aspect is most useful in metropolitan areas where HOV lanes are used. Usually there are a minimum number of people per vehicle that can use the lanes and some cities provide incentives for multi-passenger travel. The incentives could include free parking, no toll charge for using the HOV lane and the like. In a research article by Burbank and Nigro, they assert that ridesharing represents a cost-effective means for handling many concerns such as congestion, energy consumption and greenhouse gas emissions. Burbank et al. report that 70 percent of the U.S. consumption was for surface transportation in 2010. Surface transportation currently generates more than 20 percent of all greenhouse gas emissions in the U.S. Moreover, in 2011 Americans spent the greatest proportion of their income on gasoline and due to federal, state and local budgetary trends; it is not likely that additional funding will be allocated to increase transportation budgets. Single occupancy vehicle travel is still the most dominant form of travel in the U.S. Burbank et al. state that in 2009 a whopping 76 percent of commuters did so in single occupancy vehicles (SOV) up from 63 percent in 1983. The data is clear that there is a lot of opportunity to reduce congestion and energy consumption just by implementing some form of carpool or vanpool for commuters. A study by Dillenburg, Wolfson, and Nelson concluded that an increase of 4 percent of the number vehicles with multiple passengers would have been enough to offset the congestion in the nation's largest 68 metropolitan areas in 1999. This excess congestion cost the United States economy over $78 billion from fuel and wages alone asserts Dillenburg et al. Fu, Fang, Jiang and Jiujun writes that the U.S. has about 50 percent of the world's volume of cars. "The paved street and highway mileage in the US increased only by 3% since 1980 while highway traffic increased by 48%". Congestion increased by 300% between 1980 and 1999. The New York Times published an editorial by Mickey Meece in which Mickey laments "Ridejoy plans to introduce digital identification verification and background checks to its safety mechanisms which include Facebook integration, user reviews and references, plus a safety checklist will be sent to users".

Taken together, the results indicate people in the U.S. are willing to rideshare but remain hesitant due to the lack of trust, potential safety risks, less flexibility, and few route matching algorithms. There should be substantial proof that progress has been made to mitigate fear of sharing rides with people you may barely know. However, due to technological advances and social networking popularity, fear of ridesharing is becoming less of a problem. As our culture changes in United States we will become more willing to share rides with people we don't know because of the access to personal profiles and other pertinent information. Ridesharing just 2 days per week would be enough to change the energy consumption conversation in our country. Congestion would be drastically reduced and time spent in rush hour traffic radically changed or possibly eliminated by implementing some type of ridesharing scheme. We should continue to improve whatever system implemented to make sure people feel better about the trust and safety issues. Trust and safety are by far the primary factors impeding the use of ridesharing.

Results

The potential impact ridesharing could have on the preservation of natural resources is tremendous. Just think, instead of one person driving to work alone, if there were 4 people riding then that would translate into a reduction of 75 percent of resources. Upon closer observation, traffic would be reduced by 75 percent, gasoline usage would be reduced by 75 percent and needed parking lot space would be reduced by 75 percent. As an experiment, the RET Rideshare team, consisting of Kim Garrett and Jesse Bell, provided other RET team members with GPS tracking devices for a 5 week period and recorded their daily travel trajectories. Figure 1 depicts a rideshare opportunity on a scheduled RET field trip to the water research station near Denton, Texas.

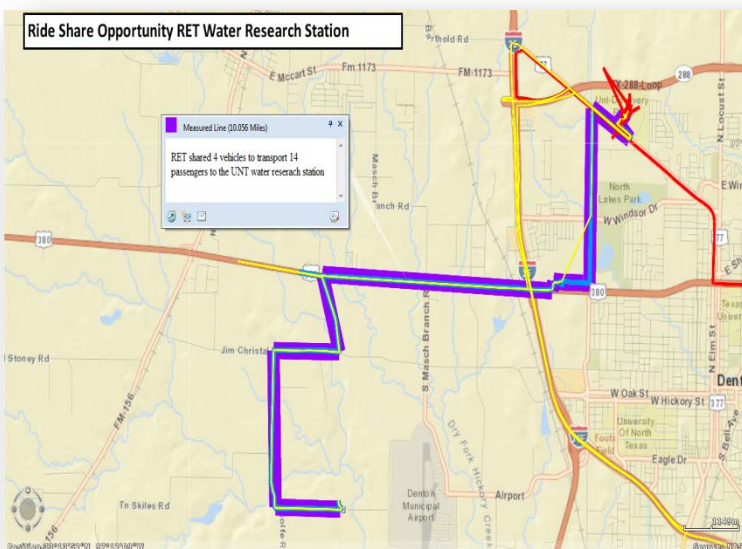

Figure 1

The blue color shows the route taken to the station. Fourteen people were transported to the research station in 4 different vehicles. There were 3 people in the first vehicle, 5 people in the second vehicle, 2 people in the third vehicle and 2 people in the fourth vehicle. After calculating the carbon footprint, we found that we could have used only 40 pounds of carbon dioxide instead of the 140 that was expended. Figure 2 shows a rideshare opportunity between Sharon and Kim. Sharon's route is shown in red and Kim's route is shown in blue. Of the 13 pounds used they could have rideshared and used only 6. The 7.8 common miles are shown in gold. Figure 2 also reflects a rideshare opportunity between Jesse and Sharon. Of the 30 pounds of carbon dioxide, 17 could have been saved if everyone used the same vehicle. Jesse's route is in blue and is NB I35 while Sharon's is also NB I35 and indicated by yellow. Figure 3 shows yet another rideshare opportunity between Sharon, Jennifer and Jesse. Jennifer, Sharon and Jesse's routes are represented by the blue, yellow and red lines respectively. A total of 63 pounds of carbon dioxide was used during the 20 mile common route. If the three had rideshared and Sharon's vehicle used to transport the three to Denton, only 19 pounds of CO_2 would have been consumed

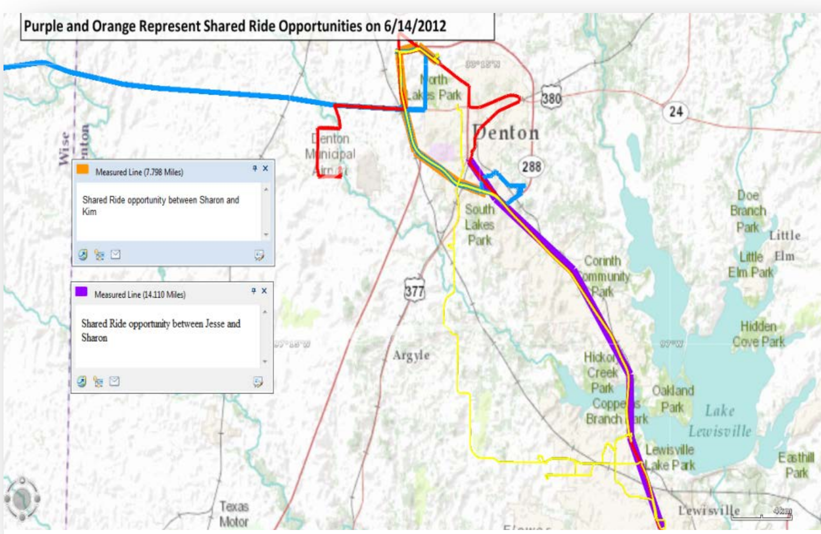

Figure 2

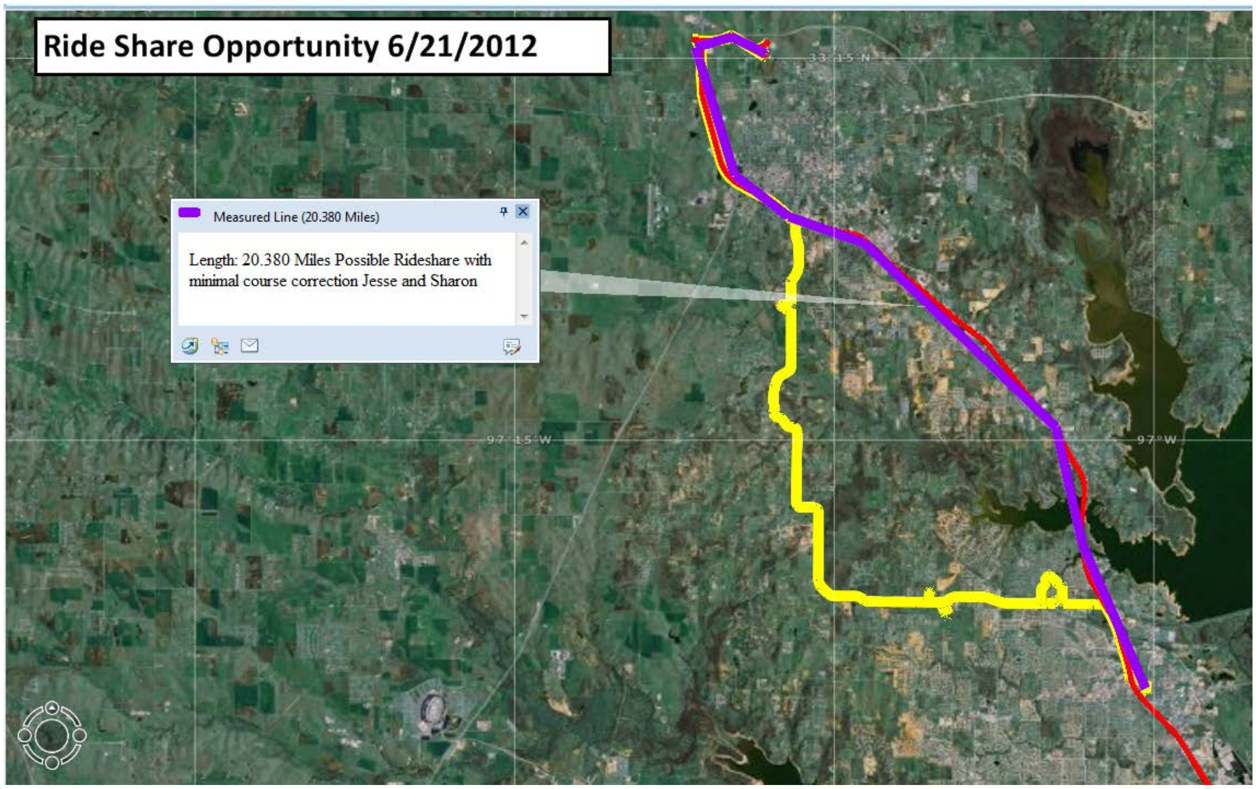

Figure 3

Figure 4 is evidence of another rideshare opportunity. Kim used 3 pounds of CO_2 and Jesse used 4 pounds for a total of 7 pounds expended possibly resulting in a 57 percent reduction of the common route for the trip by ridesharing. Figure 5 depicts an opportunity by Jesse (red) and Sharon (yellow) to rideshare. Their total carbon footprint for the segment is 11 pounds. Ridesharing would have resulted in an over 50 percent reduction as well.

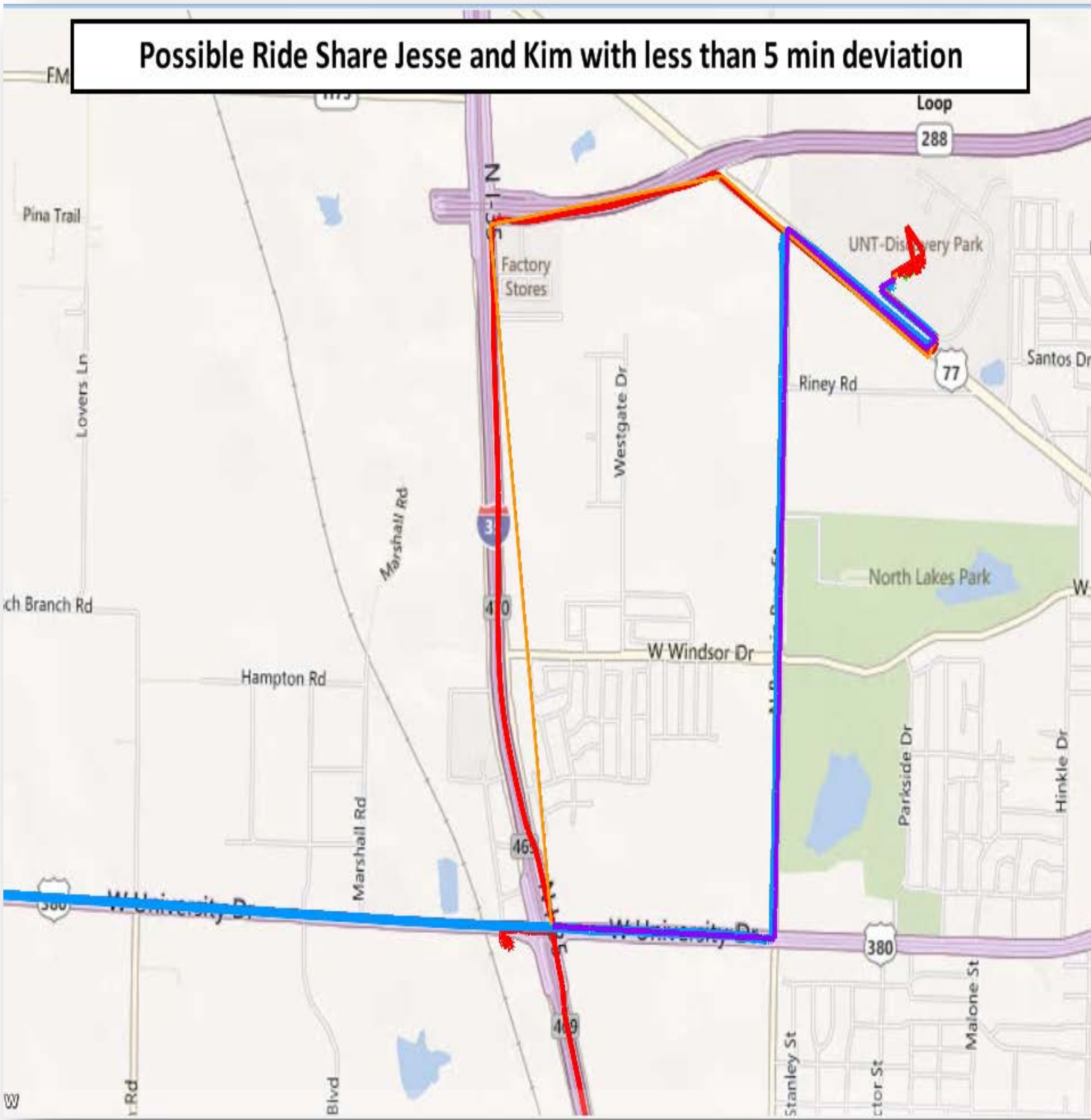
Possible Ride Share Jesse and Kim with less than 5 min deviation
Loop
288
Pina Trail
Factory
Stores
Lovers Ln
Westgate Dr
Riney Rd
Santos Dr
77
Marshall Rd
North Lakes Park
W Windsor Dr
Hampton Rd
Parkside Dr
Hinkle Dr
380
Malone St
Stanley St

Figure 4

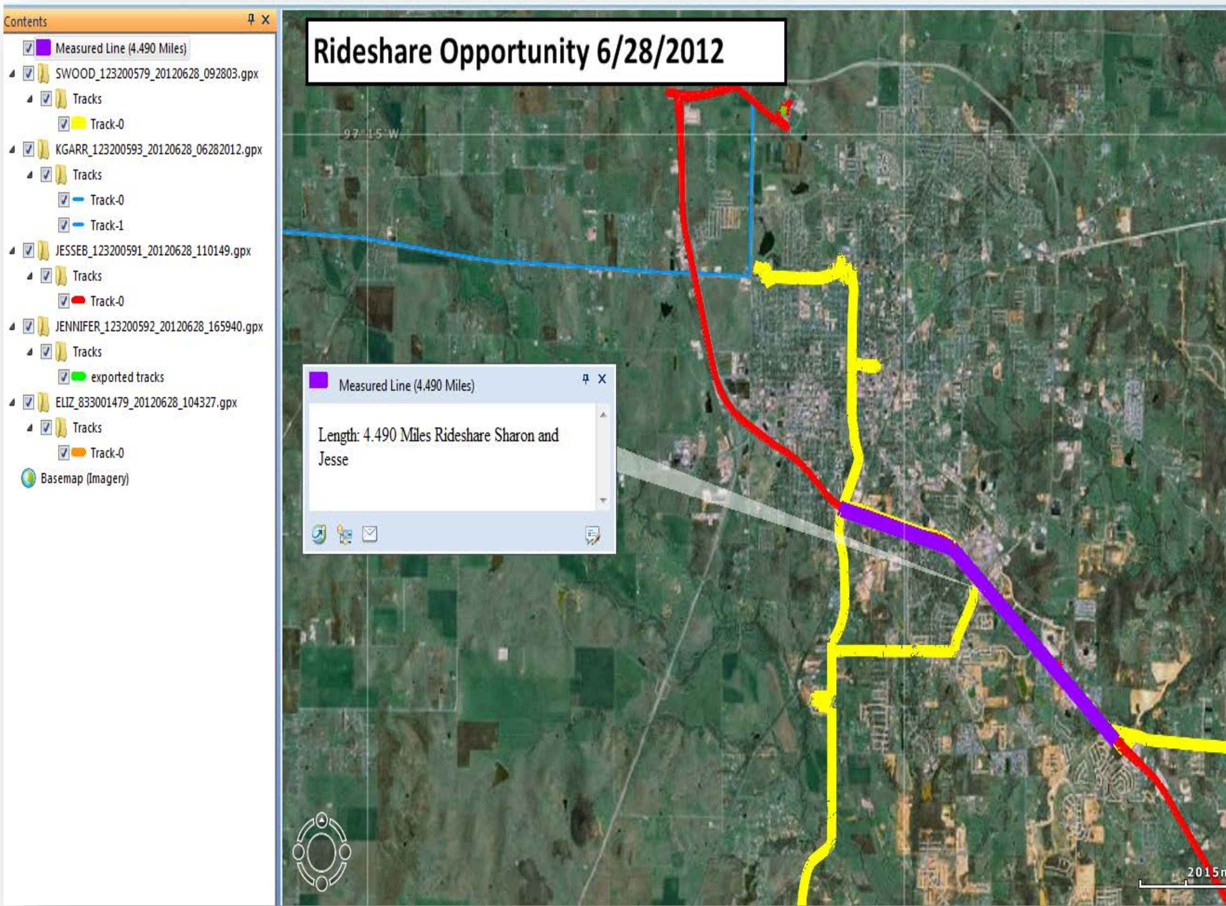

Figure 5

In figure 6 the rideshare opportunity is approximately 3.3 miles. Since Kim's travel distance is 24 miles and Jesse's travel distance is 34 miles, ridesharing for the 3.3 miles would not likely generate much interest. Figure 6 portrays the possibility of 3 member's potential to rideshare for a 20 mile stretch. Sharon (yellow), Karl (blue) and Jesse (red) exhausted 19, 13 and 24 pounds of CO_2 respectively, a whopping 77 percent reduction for the stretch. It is apparent from the data collected over the 5 week period, that there can be considerable savings to the energy resources this country needs on a daily basis. Compared to most European countries, the U.S. is far behind

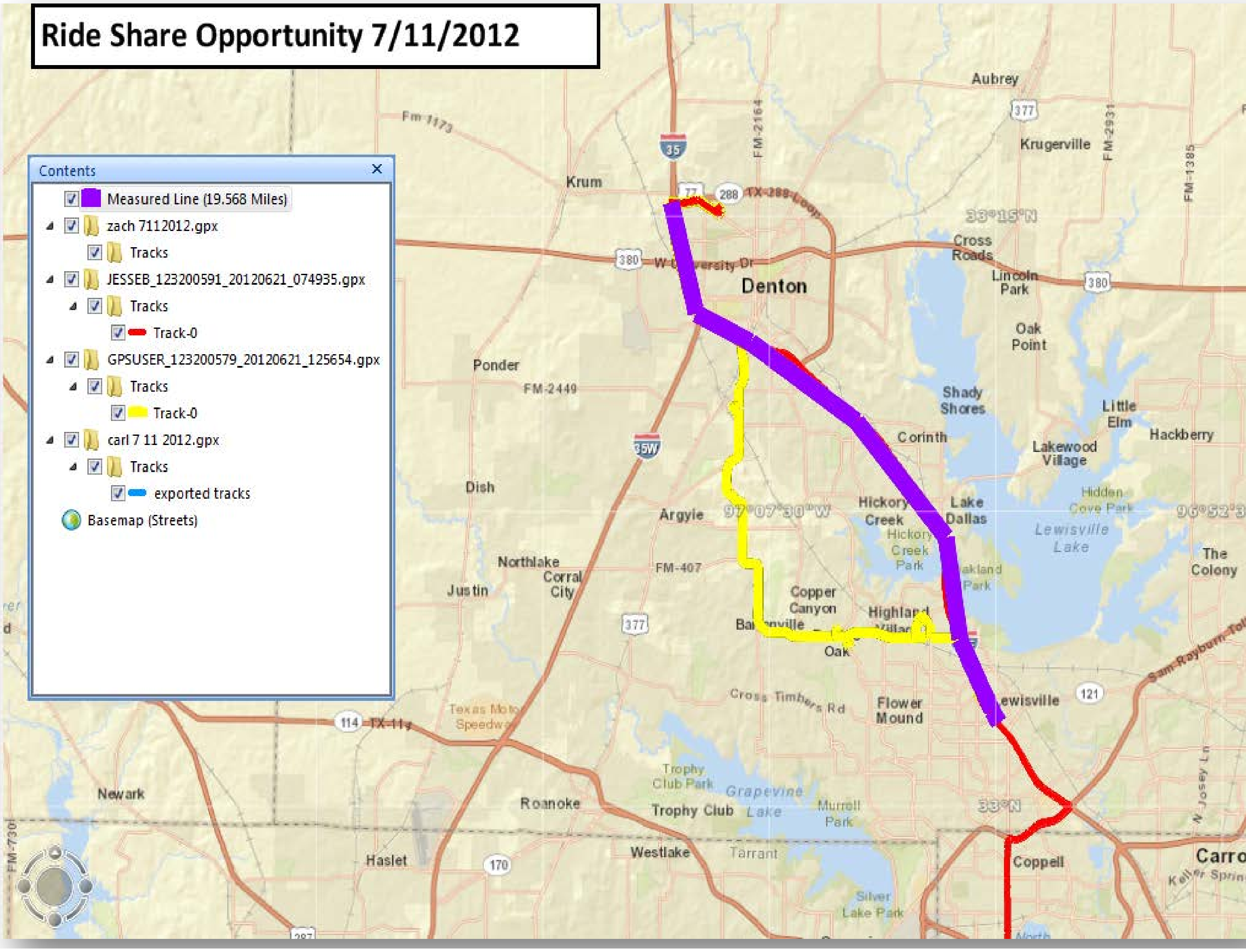

Figure 6

in adopting a ridesharing culture. The paradigm shift is slow to gain momentum in the U.S. primarily because Americans tend to be very independent minded. In addition, Americans are so time management oriented that schedules tend to be less flexible and therefore by nature not as conducive to ridesharing. Also, the American culture places a high value on the trust factor. Time and time again trust and safety issues rise to the top of in surveys as reasons why people will or will not consider ridesharing.

Our own survey revealed that 50 percent of the respondents said they would rideshare no question but another 25 percent said they would only after getting to know the other party. The remaining 25 percent replied they would not consider ridesharing at all. Interestingly, the 25 percent that would not consider at all also said they would consider if their employer provided incentives and if they knew the other party.

Recommendations

Based upon the research we have done, we think that for future implementations of ridesharing programs in this country to be successful, the following issues must be addressed and made trivial. First, until there is a huge paradigm shift, employers and municipalities have more leverage by providing incentives for their employees. This also helps to reduce anxieties associated with trust and safety since both parties by default will have a relationship or a common bond. Second, flexibility concerns would be minimized because everyone's destination is the same no matter what route taken. Once the novelty wears off and others see that ridesharing works for enterprises and municipalities, it will take a foothold in other areas as well. China is struggling with ways of reducing congestion as well. The Rideshare team received some data captured by taxi drivers in Shanghai. The preliminary analysis showed that Shanghai would benefit tremendously from ridesharing from both an energy conservation/carbon footprint and clean air standpoint due to the plethora of taxi's traveling daily with only one passenger.

Figure 6

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RET: Research Experiences for Teachers
In Sensor Networks
Summer Internship 2012
University of North Texas (UNT)
NSF - 1132585

Shared Ride: Transportation, Carbon Footprint And Ridesharing

5 E Lesson Plans

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Lesson Objective(s):

1. The students will collect travel trajectories to calculate carbon footprints using different modes of travel and investigate methods to reduce it.
2. Students will use Global Positioning Systems (GPS) to collect, calculate, and translate mileage into energy consumption through small scale vehicle activities.
3. They will visualize mileage using Global Information Systems (GIS) or Google Earth to determine paths where energy consumption could be altered or shared.
4. Students will analyze the data and learn ways to reduce energy consumption through methods such as ridesharing and public transportation.
5. Students will discover and consider the benefits and drawbacks with rideshare and public transportation such as social issues, safety, time costs and coordination efforts.
6. Students will use their data and methods to develop a model or plan of action for energy reduction within their campus or community and present their plans to community or school leaders.

Target Grade Level: Middle school through high school; this lesson can be applied to TEKS in both mathematics and science areas.

Science Strand TEKS:

- 6th Strand B - (7) Matter and energy- (A) research and debate the advantages and disadvantages of using coal, oil, natural gas, nuclear power, biomass, wind, hydropower, geothermal, and solar resources; and (B) design a logical plan to manage energy resources in the home, school, or community.

- 8th Strand A - (2) Scientific investigation and reasoning - (A) plan and implement comparative and descriptive investigations by making observations, asking well-defined questions, and using appropriate equipment and technology; (C) collect and record data using the International System of Units (SI) and qualitative means such as labeled drawings, writing, and graphic organizers; (D) construct tables and graphs, using repeated trials and means, to organize data and identify patterns; and (E) analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.

- Biology – (C) Knowledge and skills: 3.A-D
- Earth and Space – (C) Knowledge and skills: 3.A-D;12.D,E;13.B,C
- Environmental Systems – (C) Knowledge and skills: 3.A-D;9.J-L
- IPC – (C) Knowledge and skills: 3.A-D;4.B,C;5.D,H,I
- Physics – (C) Knowledge and skills: 3.A-D,F;4.A,B

Math Strand TEKS:

- Algebra I – Foundations for Functions: Knowledge and Skills: A.1 A-E; A.2 B
- Algebra II - Foundations for Functions: Knowledge and Skills: A.1 A-E; A.2 B

Materials Needed:

A. Data Collection Activity Supplies
   a. GT- 31 GPS or smartphone GPS devices
   b. Several free GPS apps for smartphones for both android and iphone
   c. Remote Control vehicles large enough to carry GPS devices
   d. Map or city layout on a parking area large enough to collect GPS data
   e. GPSBabel – freeware (http://www.gpsbabel.org/)
   f. Google Earth or GIS software – freeware (http://www.google.com/earth/index.html)
   g. GIS software – some freeware versions are available: (topofusion.com/download)

Engagement:

A. Students will watch video clips on what a carbon footprint is, what global climate change is, what GPS is and how it can be applied to vehicles. See video links below, and click, all are found through YouTube and Teachertube. Carbon Footprint Intro, Incredibles GP intro ; GPS How Does it Work?;

B. Student directed inquiry activities:
   a. In what ways do you contribute to your carbon footprint?
      i. Have students complete a carbon footprint calculator exercise: http://footprint.stanford.edu/calculate.html
         (Access a hard copy and online versions here)
   b. How does your transportation footprint compare to your classmates? US average? Globally?
   c. How does GPS find you?
   d. How many satellites does it take to have worldwide coverage?

Exploration:

A. Students will measure and visualize distances and measure tracks using GPS.
   a. They will drive a course outside completing a list of tasks or going to a list of locations.
   b. Students will measure the distances by hand and by uploading their GPS data. (Physics students can use vector addition to calculate distance, displacement and average speed)
   c. Students will convert GPS data into a visual format in either a GIS or Google Earth in to determine if there was a better route they could have taken that would save displacement or travel.
   d. Class Discussion:
      i. What are the benefits of ridesharing? Can you save money on gas, commute with friends, etc?
      ii. What are the environmental benefits of ridesharing? It reduces the amount of greenhouse gases in the air.
      iii. Do you know of anyone who shares rides? Answers will vary.
      iv. Could you or your parents have a ride share in your neighborhood? Answers will vary.

   e. Students will use the energy conversion chart in Google tables to convert mileage to energy consumption.
   f. Students' will compare their data with other students in team to determine if they could find ways to share or reduce energy consumption.

B. Questions which may be used to encourage and/or focus students' exploration:

a. What are some of the benefits and drawbacks of having GPS so readily available?
b. Why is important to have such accurate time and location information from your GPS?
c. Find ways to reduce your total travel displacement.
d. By what percentage could you decrease the energy consumption of an SUV, compared to a smaller fuel efficient vehicle? (HINT: look at the conversion tables)

Explanation:

A. Have each team research and create a method to share out each teams data and findings:
   a. What types of scheduling and coordination issues are involved in ridesharing and public/shared transportation?
   b. What are some safety concerns and possible solutions with ridesharing and public/shared transportation?
   c. How could you address concerns with time loss or other concerns drivers have?
   d. Does public/shared transportation or ridesharing a small amount really make a difference in energy consumption enough to change our carbon footprint within our community?
   e. Social discomfort is a large distractor from utilizing public/shared transportation or ridesharing. How can we encourage participation and remedy common misconceptions?
   f. With the availability of smartphone technology and GPS, research and discuss some of the opportunities that are offered on our phones.

Elaboration:

A. Students will develop a more sophisticated understanding of the concept through the following activities using their answers to their research questions above:
   a. Students will design a model or action plan to help reduce transportation energy consumption within their school or community.
   b. They will design and present their action plan to a group of community leaders or school administrators.

B. Scientific terminology to be introduced and to enhance/connect to students' travel trajectories:

   Carbon footprint
   Global climate change
   Rideshare
   Public transportation
   CO_2
   Emissions
   GPS
   GIS
   Track/waypoint
   Vectors
   Data analysis
   Data mining
   Transportation
   Car-sharing
   Carpooling
   Vanpooling

C. Application of this scientific knowledge in our daily lives:
   a. How can you encourage large urban areas to reduce their carbon footprint by adapting their transportation patterns?
   b. What other areas of your daily life could be affected positively by your choices to rideshare?
   c. Would you be able to reduce your carbon footprint in other areas simply by changing your transportation habits? Explain what areas and how you might accomplish lowering your footprint.

Evaluation:

How will students demonstrate that they have achieved the lesson objective?

a. Track and collect accurate GPS data with few outliers.
b. Calculate energy consumption for vehicles from mileage showing all work associated
c. Compare GPS routes to determine methods of carbon footprint reduction using graphs and charts
d. Successful/ Effective presentation of a plan to reduce carbon footprints of their school or community

Background for Teacher

Ridesharing can reduce the number of cars on the road. There are many websites and smartphone technologies which provide opportunities for ridesharing to common destinations.
This lesson will focus on understanding why it important to rideshare, how GPS technology works and how we can rideshare to and from school, work, sports practices, and after-school activities. Students will be able to calculate their energy usage converted from their miles travelled ridesharing. The application of this data allows the development of a plan that reduces emissions through better planning using various forms of ridesharing.

Teachers will use the carbon footprint video clip to introduce and define Global Climate Change and carbon footprints. Depending upon the background knowledge of the students, the teacher may want to introduce or review different types of fuels such as coal, gas, oil, nuclear, hydroelectric, etc. and their consumption, along with different modes of transportation such as rail, truck, ship, air, etc. Using a chart and brainstorming, students can identify the different parts of transportation and how they contribute to the carbon footprint.

Teachers next introduce GPS and the history of satellites and how GPS tracks using the video and discussion questions. The activity “Mapping my ride” will engage students in collecting, analyzing and visualizing their GPS data and their miles travelled in a day.

Resources:

Student Activity: Mapping My Ride

Objective:

- The students will collect travel trajectories to calculate carbon footprints using different modes of travel and investigate methods to reduce it.
- Students will use GPS to collect, calculate, and translate mileage into energy consumption through small scale vehicle activities.
- They will visualize mileage using GIS or Google Earth to determine paths where energy consumption could be altered or shared.
- Students will analyze the data and learn ways to reduce energy consumption through methods such as ridesharing and public transportation.

Materials:

- GPS units
- RC vehicles
- Boxes for mock town
- Tape/sidewalk chalk/or tickertape for roadways
- GPSBabel (freeware to convert GPS data)
- Google Earth (or other GPS freeware programs such as ArcGIS Explorer)
- Teams of 3-4 will work best for this activity

Instructor Setup:

- Create a mockup of a city or town large enough for students to maneuver an RC vehicle.
    - Might want to scale up a version of your local community using boxes for locations such as schools, grocery stores, town hall, library, parks and game fields etc.
    - Outside you can use sidewalk chalk in a large open space.
- Draw or tape major roads or intersections.
- Make sure you know the scale size or if you are adventurous, have your classes design and build the town, scaling up a map that you provide them.
- Make sure all RC vehicles will allow for a GPS unit to be secured to them (could even use smart phones if students have access to them)
- Create a set of tasks or locations each student must complete
    - 4-6 different sets you could even laminate them for later use
    - Make it a competition to see which team can reduce their energy consumption the most

Notes:

If you do not have access to GPS, computers and RC vehicles you can still do a scaled down version of this activity by printing out maps, laminate them, and have students use dry erase markers to find the distance travelled to calculate their energy consumption. Just remember to give them a scale of the map. If you have access to computers, students could map their routes in Google Earth using the ruler function and measure their mileage. Get creative, no RC car or no GPS: use string and have them create a trail on a large map outside or on the floor.

Objective:

Collect travel trajectories to calculate carbon footprints using different modes of travel and investigate methods to reduce it utilizing data and graphical analysis.

Introduction:

GPS stands for Global Positioning System; it refers to a system of 24 satellites that orbit the Earth sending signals to receivers. Originally designed for military use, it is now popular with onboard navigation systems in vehicles and even outdoor enthusiasts. Everyday people travel miles in our vehicles running errands, going to and from work and school, or vacations. The average vehicle in the US contains 1.6 persons per vehicle mile. Every mile you travel can be converted into energy consumption which alters the carbon footprint of individuals, our country, and our planet.

Terminology:

Define the following before beginning the activity.

Trajectory,

Problem:

Is it possible to collect GPS data and use it to determine methods to reduce your energy emissions?

(Write a correctly formatted hypothesis using at lese two complete sentences)

Procedure: Part A- measuring mileage and calculating your vectors
Be sure that you show work for all your data collection and math manipulations in your data journal.

1. Obtain a set of locations or task list from your instructor and the scale factor for your community setup.
2. Measure with a string and tape the distance and directions you travelled for each task. Develop a data table that shows your distance and direction data for each trajectory.
3. Determine your total miles travelled by adding all of your trajectories.
4. Determine your total displacement by adding your vectors.
5. Attach your GPS unit or smartphone to your RC Vehicle. (make sure your GPS is collecting data)
6. Drive your vehicle following your task list using the same trajectories you measured by hand.
7. *Upload your data to the shared file for your class period; be sure you put your group name as the file name.
8. *Using GPSBabel, convert your file to .gpx format and save it. Again using GPSBabel, convert your file to .txt and save it.

   * Teachers may wish to collect and upload data for each period or have classes keep track of their own files or convert them for students to save time and technical issues.

Procedure Part B- Interpreting your data

1. Open your .txt file and you will see your miles travelled. Calculate your total miles travelled. How does this data set compare to the data you collected by hand?
2. Open the Excel file for converting mileage into energy consumption, you can also find several of these online. Plug your data in and determine how much CO_2 you produced. How does your energy consumption compare to others in your group? How does your data compare to the US average of 12,500 lbs CO_2 per yr? Divide this number and determine your daily consumption and record in your daily log.

3. *Use a program such as ArcGIS Explorer to upload multiple tracks for an entire team, and change the color or symbols for each person in the group.
4. Were there places where your paths overlapped? How long were these distances? Log this in your data.

Procedure Part C- Rideshare

1. *Use a program such as ArcGIS Explorer to upload multiple tracks for an entire team, and change the color or symbols for each person in the group.
2. Record the distances for any overlapping tracks. Record any distances where your tracks are very close together and could be combined.
3. Are these distances good opportunities for ridesharing? Justify your response by calculating the energy saved by sharing a vehicle.
4. Look for ways to reduce the total distance you travelled by combining trips or altering your trajectory. Justify your response by calculating the energy saved in decreasing your total miles travelled.

*You can have teams highlight their trajectories on a map with different colors to look at where their tracks overlap or are similar. Students can use a ruler to measure their miles travelled.

Discussion

1. Which method GPS or hand measurements produced the most accurate results? Use data and background information to write a complete response.
2. Based on your data do you see ridesharing as a viable method to reducing energy consumption of vehicles in your community?
3. Could you utilize GPS or GIS before you leave to calculate the most efficient routes for your vehicle? Explain your answer and include the benefits and barriers to using GPS for the purpose of vehicle energy reduction.

[SET UP/INSTRUCTOR PAGE]

Objective:

- The students will collect travel trajectories to calculate carbon footprints using different modes of travel and investigate methods to reduce it.
- They will visualize paths where energy consumption could be altered or shared.
- Students will analyze the data and learn ways to reduce energy consumption through methods such as ridesharing and public transportation.

Materials:

- RC vehicles
- Boxes for mock town
- Tape/sidewalk chalk/or tickertape for roadways
- Worksheet

Instructor Setup:

- Create a mockup of a city or town large enough for students to maneuver an RC vehicle.
  - Might want to scale up a version of your local community using boxes for locations such as schools, grocery stores, town hall, library, parks and game fields etc.
  - Outside you can use sidewalk chalk in a large open space.
- Draw or tape major roads or intersections.
- Make sure you know the scale size or if you are adventurous, have your classes design and build the town, scaling up a map that you provide them.
- Create a set of tasks or locations each student must complete
  - 4-6 different sets you could even laminate them for later use
  - Make it a competition to see which team can reduce their energy consumption the most

Tech Fest: Vehicle Footprints

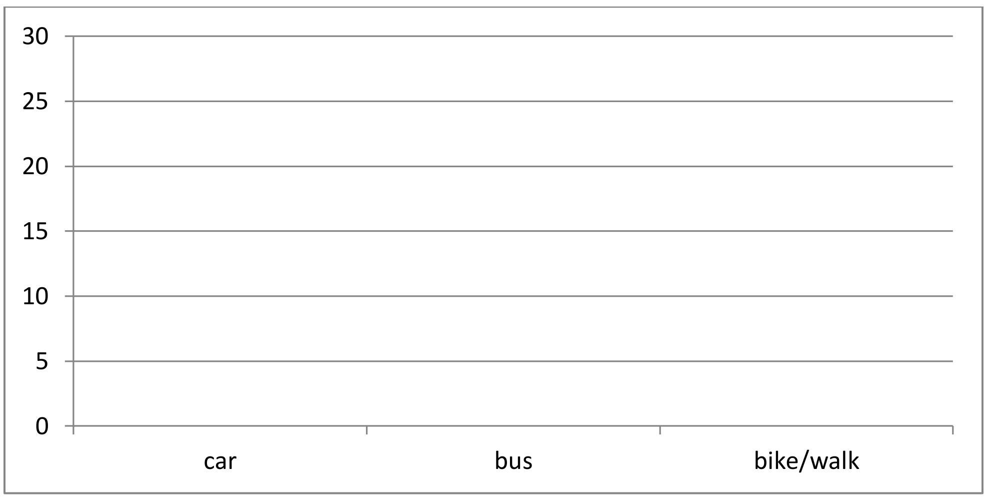
1. Choose 3 task cards. Drive to each location and write down the distance to get there.

   task 1 ___________ + task 2_____________ + task 3________________= ____________total miles

2. Write in the total miles and multiply by the type of vehicle driven to see how much emission you emitted.

vehicle	conversion factor	Total miles Driven	lbs CO_2 per mile traveled
car	1.2		
bus	0.5		
Bike/walk	0		

3. Make a bar graph to show how much energy was consumed.



a. Write down some ways you could reduce the amount of emissions your produce every day while driving.

Household Vehicles

Enter your data

Vehicle 1	10	Miles driven	1	enter **1** if this represen per day or **2** if it's miles
Vehicle 2		Miles driven	1	enter **1** if this represen per week or **2** if it's mil year
Vehicle 3		Miles driven	1	enter **1** if this represen per week or **2** if it's mil year
Vehicle 4		Miles driven	1	enter **1** if this represen per week or **2** if it's mil year

34.3 mi is about average in the United States per vehicle.

If you don't know your car's fuel economy, you can look it up at https://www.fueleconomy.gov The national average is 20.4 miles per gallon.

Estimated pounds of carbon dioxide/year			lbs per vehicle	passengers
ts miles s per year	20.4	Miles per Gallon	9 lbs	3
ts miles es per	22.0	Miles per Gallon	10 lbs	4
ts miles es per	22.0	Miles per Gallon	10 lbs	5
ts miles es per	20.0	Miles per Gallon	11 lbs	2

10	Pounds of carbon dioxide	Emissions = Sum of vehicles 1-5: (number of miles driven per day for vehicle #1 * 1) / average household fuel efficiency of vehicle #1 * pounds of CO2 emitted per gallon * emissions of greenhouse gases other than CO2	pounds of CO2 emitted per gallon emissions of greenhouse gases ot

88 pounds is about average per vehicle

= 19.4
her than CO_2 = 100/95