

On the Road Again

Student Objective

The student:

- will be able to explain ways that people and families can cut their CO₂ emissions
- will calculate the fuel usage and efficiency of various vehicles
- will determine their family's transportation/carbon footprint
- will record their family's transportation usage, and calculate class averages

Key Words:

carbon footprint
efficiency
emissions
mass transit

Time:

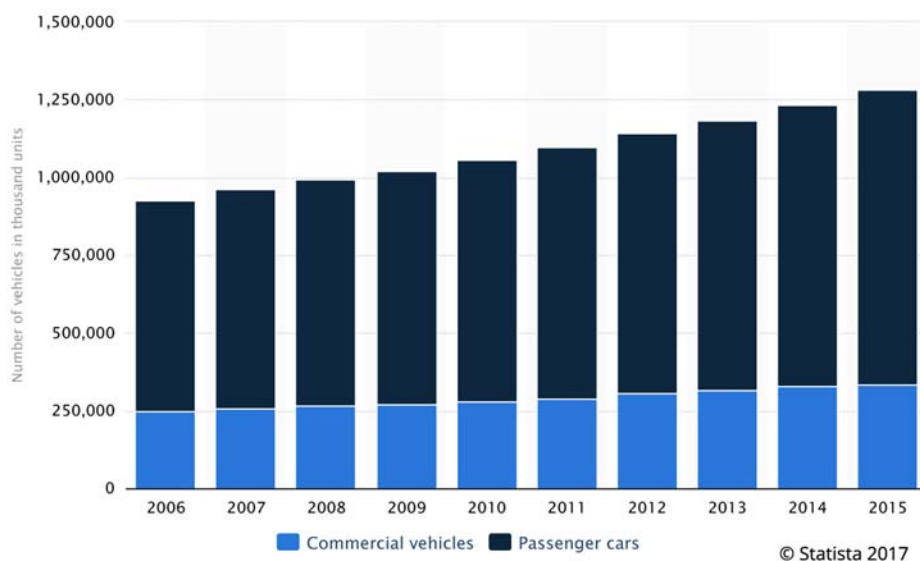
½ class period for assignment
1 class period for data compilation,
discussion & follow-up

Materials:

- Laboratory Manual

Background Information

The number of cars worldwide is increasing, topping 1 billion passenger cars in 2016. In the U.S. our per capita vehicle ownership is the highest in the world at 1:1.3. But since this figure includes the whole population regardless of age, health or location, it is also interesting to note that in the U.S. there is statistically 1.0 vehicles for every licensed driver and 1.87 vehicles per household!



The increase in world car ownership is driven in a large part by the Chinese market which is the fastest growing automobile market in the world, having an increase of over 10% for the past few years (compared to US sales increasing less than 1%). The growth in the Chinese market can be attributed to their previously low vehicle ownership rate (.04%), rising incomes, greater credit availability and falling car prices. Also interesting is the fact that China is currently leading the world in vehicle manufacture.

Mass transportation systems in the United States include buses, trolleys, trams, ferries, and a variety of trains, including rapid transit (i.e. subways), light rail, and commuter rail. Intercity public transport is dominated by airlines and intercity rail. Although the U.S. has over 140,000 miles of existing rail lines, they are used almost exclusively to move freight. The U.S. also has 15 city subway systems, however, none of them is connected to another city. And even though New York's subway system has a ridership of about 9 million a week, only 5% of Americans report using public transportation "every day or most days", and 61% report never using public transportation.

In countries like the U.S., choosing a transportation method other than the automobile is not always simple. Our cities have been designed around the car. Few of us live close to where we work or shop. In Europe, which has fewer private cars, cities are much more dense, making alternatives easier and more attractive. Breaking our dependence on cars in the long term will require us to redesign our cities so that alternative modes of transportation will become easier.

Procedure (assignment day)

1. **Engage:** Show the video *Global Issues through Our Lens: Transportation* (link to video is in Internet Sites section)
2. Facilitate a class discussion on points made in the video.:
 - when Erika says 'there is no perfect solution to this problem', what does she mean?
 - Amory Lovins states in the video that the transportation issues include cultural, policy, competitive strategy & business models, and design. Can you think of examples for each of these issues?
 - do you agree with Erika that we will move away from cars in the future?
 - Erika states that we need to use what we have more efficiently. What are some of the ways we can do this?
 - Erika also states that we have technology solutions that are available that we could implement very quickly. What do you think she is referring to?
3. Conduct a quick class survey of the total number of fossil-fuel powered vehicles owned by the student's families including motorbikes, boats, jet skis, etc., and calculate the number of people per vehicle this represents. Lead a discussion about these numbers. Points to include are:
 - in China there are as many as 200 people for every vehicle; in the U.S. there is statistically 1.0 vehicles for every licensed driver and 1.87 vehicles per household—the highest per capita ownership in the world. (*How did your data compare?*)
 - there are currently over 1 billion passenger cars in operation in the world today, with over 60 million new cars being produced every year

- North Americans have the highest per capita carbon dioxide emissions in the world, with the U.S. ranking first
 - our personal vehicles account for nearly one-fifth of all U.S. emissions—around 24 lbs of carbon dioxide and other global warming gases for every gallon of gas (5 lbs from ‘upstream’ pollution and 19 lbs out of the tailpipe)
4. **Explore:** Tell the students that they will be creating a transportation log and collecting data for one week (*or two, at your discretion*) on their families’ transportation. In this log they will be recording the lengths of the trips, how many people are transported, the amount of fuel used, time of day and weather (raining or not!). Explain to the students that their data will then be combined into a class-wide data set that they will then analyze.
 5. Have the students look at the log example in their Laboratory Manual and answer any questions that they might have about the process. Be aware that some students may be reluctant to share personal data, so the data collection should be as objective and quantitative as possible.
 6. Assign the date for the logs to be turned in. (Note: 1 - 2 weeks time is optimal to get a good set of data, however, students will need to be reminded of the assignment periodically so they stay on task!)

Procedure (data compilation day)

1. On the board or on sheets of flip chart paper, write the headings:
 - Family vehicle #1
 - Family vehicle #2
 - Family vehicle #3 (if you think your class will need it)
 - Bus/Public Transit
 - Car pool
 - Recreational Vehicle
 - Bicycle
 - Walking
 - Miles per person, Day #1
 - Miles per person, Day #2, etc.
 Have extra markers ready.
2. Explain to the students that they are to write their totals for each type of transportation in a column under the headings. If the total is for an electric, hybrid, or other alternative fuel vehicle they should tag the total (E, H, or ALT). To increase anonymity, give the students several minutes and let them come up and record their totals as they wish.
3. After the students have all recorded their totals, ask for volunteers to:
 - for each column, calculate the total, the class average, and the daily per class member average
 - calculate a grand total, the total average and total class average for the vehicles with emissions
 - calculate a grand total, the total average and total class average for the transportation that doesn’t have emissions (walk, bike)
 - calculate a total class average of the miles per person per day

Take a couple of minutes and have the class look over the data and calculations to see if they all seem valid or if there are some that need double checked for recording or accuracy in calculations.

4. **Explain:** Instruct the class that together they are going to make a graph (or several graphs) of the data that best ‘tells the story’ of their transportation usage. Lead a discussion on how the graph should be fashioned. Things to discuss could include:
 - what parts of their data are the most interesting or important to represent visually?
 - who would be their target audience for this graph?
 - what point would they be making with the graph?
 - what type of graph (line, bar, pie) would work best for their purpose? What should be on each axis? What scale should they use?Have the students work together to create the graph(s). If they can’t decide on just one message or data set to represent, let them split into separate groups to finish multiple graphs.
5. **Extend & Elaborate:** Discuss with the class the *reasons* behind their behavior and any possible solutions.
 - Why do you think there were so many short trips (or long trips) in your class? What does that say about the area where you live?
 - 78% of trips in the United States are under 40 miles a day. How does your class compare? Why do you think your class has more (less) miles per day?
 - What does the per person average say about the way they travel? What could be done to encourage car pooling?
 - Why is there such a big difference between the amount of miles via personal car and public transportation? What could be done to make public transportation more appealing?
 - Why do they have so few trips walking or biking? What could be done to make this a more attractive option? What barriers are standing in the way of walking/biking more?
6. Help the students brainstorm ways that things could be changed in the future to include more green transportation options.

Key Words & Definitions

- **carbon footprint** - a measure of the impact a certain activity has in terms of CO₂ emissions
- **efficiency** - the ratio of useable energy coming out of a process to the total energy being input into a process
- **emissions** - the production and discharge of something. Vehicle emissions are the gases and pollutants emitted by the engine through the tailpipe.
- **mass transit** - public transportation including buses, trolleys, ferries, trains, subways, and airlines

Related Research

1. Using your classroom data, calculate the classroom’s transportation carbon footprint.

2. Obtain schedule and route information for your local mass transit system and analyze the system for ease of use for different routes such as for: work (8:00-5:00); night shift work; grocery shopping; a doctor's appointment; and for recreational use. How could your local mass transit be improved? What improvements could be made economically?
3. Design a city of the future to accommodate transportation. Include mass transit, bicycle and walking options as well as electric vehicle charging stations.
4. Using the information collected, have the class make a flyer or a webpage on ideas for individuals and families to reduce emissions.

Related Reading

- ***Just Ride: A Radically Practical Guide to Riding Your Bike***, by Grant Petersen (Workman Publishing Company, 2012)
A great book for cutting through the hype and just enjoying the ride. Besides the requisite chapters on safety, equipment and maintenance, Petersen includes a chapter on Velosophy with subtitles such as 'Your bike is a toy. Have fun with it'.
- ***How Cycling Can Save the World***, by Peter Walker (TarcherPerigee, 2017)
Peter Walker takes readers on a tour of cities like Copenhagen and Utrecht, where everyday cycling has taken root, demonstrating cycling's proven effect on reducing smog and obesity, and improving quality of life and mental health.

Internet sites:

<https://www.youtube.com/watch?v=oK7cPjiZyzw>

Global Issues through Our Lens: Transportation, the 100 People Foundation, is a student driven video project that touches on the complex issue of transportation and the future of transportation.

<http://www.ucsusa.org/clean-vehicles/electric-vehicles/ev-emissions-tool>

Union of Concerned Scientists interactive emissions calculator. Enter your zip code, make and model of car and find the CO₂ emissions (from the power plant) in your area for that vehicle and how that compares to the national average.

https://www.ted.com/talks/peter_calthorpe_7_principles_for_building_better_cities

Principles For Building Better Cities, Ted Talk by Peter Calthorpe

<http://www.conservation.org/act/carboncalculator/calculate-your-carbon-footprint.aspx>

Conservation International site with a Carbon Footprint calculator

<https://www.youtube.com/watch?v=SAhZ1fA1AJs>

Time-Lapse History of Global CO₂ Emissions by Humans 1751 - 2008, Oak Ridge National Laboratory Carbon Dioxide Information Analysis Center

<https://www.youtube.com/watch?v=iH-W3gYx8vY>

Part of the documentary *Racing Extinction* that shows a camera modified to show CO₂ emissions.

On the Road Again

Florida NGSS Standards & Related Subject Common Core

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Nature of Science																					
Standard 1	SC.912.N.1.	X																			
Life Science																					
Standard 17	SC.912.L.17.															X	X				X
Mathematics Standards		MAFS.912.N-Q.1.3, MAFS.912.A-REI.1.3, MAFS.912.S-IC.1.1, MAFS.912.S-IC.2.3, MAFS.912.S-IC.2.6, MAFS.k12.MP.3.1																			
Social Studies Standards		SS.912.G.5.3																			
Language Arts Standards		Grades 9 & 10: LAFS.910.SL.1.1 Grades 11 & 12: LAFS.1112.SL.1.1																			

Standard 1: The Practice of Science

- SC.912.N.1.1 - Define a problem based on a specific body of knowledge, and do the following: 1) pose questions about the natural world, 2) conduct systematic observations, 5) plan investigations, 6) use tools to gather, analyze, and interpret data, 7) pose answers, explanations, or descriptions of events, 8) generate explanations that explicate or describe natural phenomena, 9) use appropriate evidence and reasoning to justify these explanations to others, 10) communicate results of scientific investigations, and 11) evaluate the merits of the explanations produced by others.

Standard 17: Interdependence

- SC.912.L.17.15 - Discuss the effects of technology on environmental quality.
- SC.912.L.17.16 - Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.
- SC.912.L.17.20 - Predict the impact of individuals on environmental systems and examine how human lifestyles affect sustainability.

Mathematics Standards**Numbers & Quantity: Quantities**

- MAFS.912.N-Q.1.3 - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Algebra: Reasoning with Equations & Inequalities

- MAFS.912.A-REI.1.2 - Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.

Statistics & Probability: Making Inferences & Justifying Conclusions

- MAFS.912.S-IC.1.1 - Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
- MAFS.912.S-IC.2.3 - Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.
- MAFS.912.S-IC.2.6 - Evaluate reports based on data.

Mathematical Practice

- MAFS.K12.MP.3.1 - Construct viable arguments and critique the reasoning of others.

Social Studies Standards**Geography**

- SS.912.G.5.3 - Analyze case studies of the effects of human use of technology on the environment of places.

Language Arts Standards**Standards for Speaking and Listening**

- LAFS.910.SL.1.1 & LAFS.1112.SL.1.1 - Initiate and participate effectively in a range of collaborative discussions with diverse partners on grades 9 - 10 (11 - 12) topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

National Standards

Note: Related **National Common Core Mathematics Standards** and **National Language Arts Standards** are listed in the Florida Section above.

On the Road Again

1. Create a transportation log of your family's transportation use. When you use public transportation (i.e. school bus, mass transit, etc), tag those trips and make a guess of how many people are riding at the same time. If you have more than one vehicle, tag the trips for each vehicle (use A and B, 1 and 2, or different colors of ink for each vehicle). Also include in the log any recreational/pleasure trips taken that involve fuel being used (i.e. boats, jet skis, etc)—in this case you may need to estimate how many miles are traveled.. An example of how you could set up your log is below:

date	day/night? weather conditions	purpose	# in vehicle	miles traveled	miles per person
<i>Mon</i>	<i>day/sunny</i>	<i>school</i>	<i>3</i>	<i>9</i>	<i>3</i>
<i>Mon</i>	<i>night/clear</i>	<i>movies</i>	<i>4</i>	<i>15</i>	<i>3.75</i>
<i>Tues</i>	<i>day/rainy</i>	<i>school</i>	<i>45 (bus)</i>	<i>9</i>	<i>.2</i>
<i>Wed</i>	<i>day/sunny</i>	<i>friend's house</i>	<i>1 (bike)</i>	<i>2</i>	<i>2</i>

After your data is collected, total your miles traveled by vehicle and/or vehicle type. (For example, if you have two cars in your family you will total each of those separately, and also total the other transportation methods separately). Write your totals below so you will have them handy for your class discussion:

Total the miles per person column for each day you collected data, and write your totals below so you will have them handy for your class discussion:

2. Looking at data you collected, what was your longest trip? _____
shortest trip? _____
What was the average length of your regular weekly trips? _____
(exclude any vacations or unusual trips you may have taken during the time)
3. How much fuel did your family use during this time? _____
(Hint: Get the average fuel mileage for your make and model of vehicle at the Department of Energy site: <https://www.fueleconomy.gov/feg/findacar.shtml>)
If your family has a second vehicle, list the fuel usage for it here _____
4. Assuming that the data you collected on your family's personal vehicle(s) is typical of its usage over a year, how many miles you will travel in a year? _____
5. How much fuel would your family's vehicle(s) consume in a year? _____
How much CO₂ would your family's vehicle(s) produce in a year? _____
(Hint: Get the CO₂ emissions for your car here: <http://calculator.carbonfootprint.com>)
6. The average U.S. car emits a little over 10,000 pounds, or 5 tons, of CO₂ per year. How do your transportation emissions compare? If your data shows a difference – more or less – than the average, why do you think this is so?
7. Looking over your own transportation log, what could you or your family realistically do to reduce the amount of CO₂ emissions that you are responsible for contributing to the environment?