Building Better Buses

Transportation Design Challenges

Grade levels: 6-8

Total activity time: 60-180 minutes

Materials needed:

- Video: **Buses and Biofuels: Sustainable Transportation**
- Computer with internet access and projector
- Rulers (1 per student)
- Calculators (1 per student)
- Scratch paper
- Student Activity Guides (1 per student)
- Teacher Solutions

About This Lesson

This lesson is composed of three challenges, each addressing a different aspect of how to design an efficient public bus system for a fictitious town while taking into account the benefits and drawbacks of various fuel options. All challenges involve mathematical and computational thinking and modeling that is connected not only to the NGSS, but also to the middle school Common Core math standards. Depending on the time you have and your curriculum goals, you can employ one, two, or all three of the challenges in your classroom, although we recommend progressing in order from #1 to #3 as each challenge builds on the previous one(s).

In attempting these challenges, students will find that there is often more than one way to solve a problem. The purpose of these challenges is for students to reason out their own logical methods for solving a problem using math and computational skills with little initial guidance.

Students should have a basic understanding of fossil fuels and their impacts on the environment before approaching these challenges. It is recommended your students watch the video **What's the Deal With Fossil Fuels?** and complete the accompanying activity **The Heat is On: Cause and Effect and Climate** before tackling this lesson.

Focus Questions

1. How can we use math to design a public transportation system that is cost, time, and energy-efficient?
2. How do different transportation energy sources compare in terms of cost, energy-efficiency, and impacts on the environment?

Learning Objectives

Challenge 1:

- Students will use Common Core math and computational skills, including mathematical modeling, to design the most efficient bus route for a fictitious town.

Challenges 2 and 3:

- Students will use Common Core math and computational skills, including mathematical modeling, to decide how to power a bus fleet in a fictitious town using gasoline, E85 ethanol, and/or electricity using 50% coal and 50% carbon-free renewables.

Challenges 1, 2, and 3:

- Students will be able to describe how technology can reduce human impacts on Earth's systems and human consumption of nonrenewable natural resources.
- Students will weigh the benefits and drawbacks of various transportation energy sources in terms of cost, carbon emissions, energy production, as well as social and environmental impacts.

Teacher Prep

1. Gather the materials your students will need, such as rulers, calculators, scratch paper, etc.

2. Print out one copy of the **Student Activity Guides** for each student. Print out extra copies of the Map of Downtown Solutionville on page 2.

3. For Challenges #2 and 3, you will need to look up the current price per gallon (national average) of **E85** and **regular gasoline**, and for Challenge #3, the current average price for a ton of **coal**. Have students write these prices on the appropriate Transportation Fuel Cards in their Student Activity Guides.

4. Review the **Teacher Solutions**, which give examples of problem-solving approaches students might take for each challenge.

Activity (60-180 minutes)

Warm-Up (15-20 minutes)

1. Show students the video **Buses and Biofuels: Sustainable Transportation**, and discuss.

2. Introduce students to the premise of this activity:
Imagine a fictitious town called Solutionville. The citizens of Solutionville want to make sure their community is a healthy and safe place. They decide to start improving their town by giving people more access to public transportation that is both time and energy-efficient. Imagine you are a citizen of Solutionville who has been tasked with helping to design a public bus system that would service the downtown area.

3. Ask students to discuss with a partner what conditions they think a public bus system should have to be 'time efficient.' What about 'energy-efficient'? Ask for volunteers to share their or their partners' thoughts.

4. Before moving on, create a list of criteria on the board that is student-generated.

> ***Teacher Tip:*** *You can use this exercise to both check for understanding and prepare students for their first challenge. Be sure students have made a connection between efficiency in time or distance (which is beneficial for commuters on public transit) and the savings in fuel that occurs when routes are efficient.*

Sample discussion questions for creating shared criteria:

- *What reasons might a person have for driving their own car from place to place instead of taking public transportation?*
- *Why do you think a person might try to find a shortcut to get from one place to another?*
- *What might be some benefits of public transportation?*
- *What does being 'energy-efficient' mean, and what do you think are the benefits of something that is 'energy-efficient' versus something that is not?*
- *What other factors do you think you should consider when designing your public transportation system? (E.g., environmental impacts)*

Challenge time! (45-180 minutes)

The following challenges are outlined in detail in the Student Activity Guides:

Challenge #1 (suggested time: 45-60 min): Design an 'efficient' public bus system

Challenge #2 (suggested time: 45-60 min): Compare fuels: Biofuel vs. regular gasoline

Challenge #3 (suggested time: 45-60 min): Grid or no grid?

Instructions for each challenge:

1. Divide students into pairs, hand out one Student Activity Guide (for the specific challenge) to each student, and briefly explain the challenge.

2. Assign a time limit to the challenge, and make sure this is clear to students.

3. Students will be using extensive mathematical and computational thinking to solve various problems presented by each challenge. Make sure to leave enough time at the end of each challenge for students to present their methods to their classmates. If you like, you can have students work through the problems on a large piece of butcher paper that can be displayed on the wall for others to see.

4. Check for understanding by either having a class discussion or asking students to write a reflection of their experience for homework. Discussions or reflections should address questions such as:

   - *How would you define 'efficiency'? Is there more than one kind of 'efficiency'? Why do you think we would want to make a public bus system efficient?*
   - *How do different energy sources used for powering buses compare? What are the benefits and drawbacks of each? What factors did you take into account in deciding how to power your public bus system?*
   - *Why do you think we might care how much carbon dioxide a particular energy source might produce when used? Why do we care about cost?*

Extensions

- You can extend this learning experience by having your students explore the public transportation system that exists in your community. How energy or time efficient is it? What impacts does it have on the environment or community, if any? Challenge your students to write a letter to your local government officials with recommendations for improvements.

- If your community does not have an extensive public transportation system, your students can explore the school bus system instead.

Additional Resources

- The New York Times: From China to Los Angeles, Taking the Electric Bus
- U.S. Department of Transportation: Sustainability and the Transportation System
- California Academy of Sciences: Planes, Trains, or Bicycles: Being a Low-Impact Traveler
- California Academy of Sciences: Better Biofuels

Connections to Standards

NGSS Disciplinary Core Ideas (Grades 6-8)

- MS-ESS3.C: Human Impacts on Earth Systems

NGSS Science and Engineering Practices (Grades 6-8)

- Using Mathematics and Computational Thinking
- Designing Solutions

NGSS Crosscutting Concepts (Grades 6-8)

- Influence of Science, Engineering, and Technology on Society and the Natural World

Common Core Math (Grades 6-8)

Teacher Tip: *Depending on how your students approach the challenges in this lesson, you may have opportunities to focus on one or more of the following:*

- **Ratios and Proportional Relationships:**
  - (6) Understand ratio concepts and use ratio reasoning to solve problems.
  - (7) Analyze proportional relationships and use them to solve real-world and mathematical problems.

- **Expressions and Equations:**
  - (6) Apply and extend previous understandings of arithmetic to algebraic expressions.
  - (6) Reason about and solve one-variable equations and inequalities.
  - (7) Use properties of operations to generate equivalent expressions.
  - (7) Solve real-life and mathematical problems using numerical and algebraic expressions and equations.

- **The Number System:**
  - (6) Apply and extend previous understandings of multiplication and division to divide fractions by fractions.
  - (7) Apply and extend previous understandings of operations with fractions.

Up Next in *Flipside Science* Exploring Energy:

The Heat is On:
Cause and Effect and Climate

Optimal and Sustainable:
Renewable Energy Revamp

Building Better Buses:
Transportation Design Challenges

Nuclear Energy:
What's Your Reaction?