Web Unit Plan

Title: Pedal Power

Description: Desired by 6-year olds eager to ride, rejected by teenagers eager to drive, and relied on as the primary mode of transportation for millions of people worldwide—what is it? The bicycle! Explore this unit and check out the mathematics behind this amazing and versatile machine.

At a Glance

Grade Level: 10–12

Subject sort (for Web site index): Math

Subject: Intermediate Algebra

Topics: Equations, Formulas, Functions

Higher-Order Thinking Skills: Analysis, Problem Solving

Key Learnings: Formula Evaluation, Proportions, Domain, Range, Piecewise Function, Composition of Functions, Applied Functions and Equations

Time Needed: 2 weeks, 60-minute classes, daily

Background: From the Classroom in Arizona, United States

Unit Summary

As a culminating activity to instruction in functions, linear equations, and proportional reasoning, algebra students explore the mathematics of bicycles. Students pair up to investigate one aspect of this two-wheeled wonder. Using bicycle-related relationships—such as wheel diameter and coasting distance, or frame tubing size and weight allowances—applied math formulas and data are explored in depth. Student teams use multimedia to share their learning for the benefit of their classmates.

Curriculum Framing Questions

- **Essential Question**

  How does math help us understand our world?

- **Unit Questions**

  How can we use algebra to help describe the physical world?

  How can formulas help us understand bicycles and bicycling?

- **Content Questions**

  How do you create an equation given a problem of proportion?

  How do you solve an equation for a given variable?

Assessment Processes

View how a variety of student-centered assessments are used in the Pedal Power Unit Plan. These assessments help students and teachers set goals; monitor student progress; provide feedback; assess thinking, processes, performances, and products; and reflect on learning throughout the learning cycle.

Instructional Procedures

Exploring Bicycle Mathematics

In this activity, students work out a set of bicycle-related math exercises and then solve a unique bicycle problem with real mathematical underpinnings. Finally, students teach the concept and mathematics to their classmates through a multimedia presentation.

Introducing the Project

Introduce the Essential Question, *How does math help us understand our world?* Lead a whole group discussion around the question. Give students time to put their thoughts in their math journals before asking them to share their ideas.

Next, set up the unit by conducting the following challenge:

> Ask students if they have ever noticed a bicyclist determined to not put a foot down while balancing at a red light. Have students guess what the world record is for balancing while stationary on a bicycle. (Have students guess, but do not reveal the answer yet.) Then, ask students if they think they can balance on one leg with their eyes closed for the length of time the record holder balanced on a bike. Conduct a balancing contest. Declare a winner when one student is left standing, and then reveal the world record for bicycle balancing. Believe it or not, the record is 5 hours 25 minutes! Challenge students to determine how a person can stay upright on a bicycle for long periods. (A bicyclist is constantly shifting his weight (and center of gravity) over the bicycle to remain upright while stationary.)

Discuss the interesting bicycle concepts developed in this course of study. Guide the discussion by asking students the Unit Questions, *How can we use algebra to help describe the physical world?* and *How can formulas help us understand bicycles and bicycling?* Have students think about and share their own experiences with bicycles. Encourage them to brainstorm mathematical connections related to bicycles.

Describe the goals and expectations for the project as detailed in the project description. Explain the requirements for the pedal exercises and slideshow presentation. Distribute the scoring guide and go over it in detail with students to clarify the project requirements.

Getting to Work

Review equation concepts with students. In their math journals, have students answer the Content Questions, *How do you create an equation given a problem of proportion?* and *How do you solve an equation for a given variable?* Require students to answer the questions in writing as well as with a numerical example. Ask students to share their responses with the class.

Place students in groups of four and have them work together to complete the pedal exercises. Each group is responsible for making sure that all members can explain the solutions to each of the problems. Randomly call on members from each of the groups to explain the solution of a particular problem to the whole class. Note any problems that caused particular difficulty. These should be re-taught and similar problems assigned to ensure mastery of the mathematical concepts. After the group is firm in their skills, brainstorm bicycle math research topics.

Show the bicycle math slideshow as an example of a final teaching presentation. Meet with students individually as they select topics, and help them adjust problems as necessary for appropriate math application and rigor. Allow students several days to conduct necessary research, solve the problem, input their data into a

spreadsheet (including using the formula function and creating graphs), and develop a storyboard for their presentation. After reviewing their work, have students begin developing their presentations.

If necessary, teach students how to use different software tools, such as those used for slideshows, equation editing, and spreadsheets. Distribute the spreadsheet instructions to help guide students while they create their spreadsheets, develop charts and graphs, and calculate formulas.

Showing What You Know

After students draft their presentations, have them review their work and practice their delivery with one another. Pairs should share their presentations with at least one other pair and receive feedback for revisions using the peer feedback form. The presentation materials and oral presentations should be well synchronized, and the oral presentations should be precise, accurate, and include the language of mathematics. Presentations should last from 2 to 5 minutes, with another 5 minutes set aside for fielding questions from the group. Assess students as they present their projects, using the scoring guide.

Wrapping Up

Pose the Essential Question, *How does math help us understand our world?* to students. In small groups, have students discuss the question in relation to what they have learned from conducting their own research and listening to other students' presentations. Bring the discussion back to the whole group and give students an opportunity to share what they talked about. Give students an opportunity to share real-life examples as well.

Prerequisite Skills

- Previous experience with spreadsheets and multimedia software
- Some familiarity with the following concepts:
    - Applying the definition of a function, domain, and range
    - Understanding the composition of functions
    - Building a linear equation from a slope and a point
    - Evaluating a formula or solving it for a given variable
    - Using proportional reasoning to build an equation

Differentiated Instruction

Resource Student

- Have the student work in pairs or groups and establish rules so all students participate
- Demonstrate use of spreadsheets and multimedia software
- Provide step-by-step instructions

Gifted Student

- Encourage the student to consider more challenging problems

- Direct the student to the Bicycle Power Calculator, which allows the student to manipulate a variety of inputs to achieve various outputs, at www.kreuzotter.de/english/espeed.htm*
- Provide options for how the student presents research—allow the student to present information on an interactive Web site or in an electronic newsletter format

English Language Learner

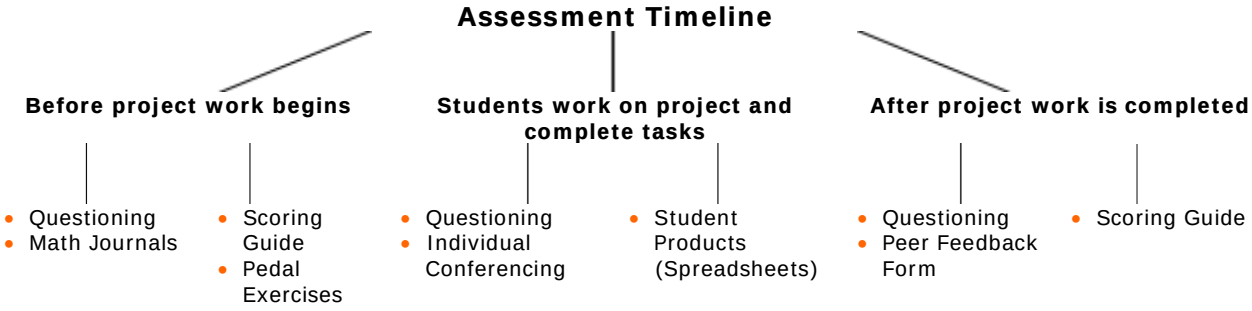
- Set the Internet browser to find sites written in the student's first language
- Provide an English translation dictionary or a handheld electronic translation device

Credits

Laura Sample participated in the Intel® Teach Program, which resulted in this idea for a classroom project. A team of teachers expanded the plan into the example you see here.

THINGS YOU NEED (highlight box)

Assessment Plan



Questioning is used throughout the unit to help students develop their higher-order thinking skills and process content. Quality of math journal entries and student products help both teacher and students to monitor progress and understanding of content. Students work on pedal exercises in small groups and discuss the meaning of the mathematical procedures and concepts they use to analyze the exercises. Anecdotal notes and group observations are used to assess the processes of problem solving and the communication of ideas. Individual conferences are used to help students select topics and answer any questions. Students practice presentations, receive feedback from peers, and make revisions based on responses from peer feedback forms. Ask students to use the scoring guide to help them self- and peer-assess work prior to completion. Use the same scoring guide to assess and grade the final presentation.

Targeted Content Standards and Benchmarks

Targeted Arizona Content Standards and Benchmarks

Patterns, Algebra, and Functions

- Describe a real-world situation that is depicted by a given graph
- Sketch a graph that models a given real-world situation
- Express the relationship between two variables using a table, equation, and graph
- Describe the relationship suggested by two or more graphs of a related real-world situation

National Council of Teachers of Mathematics (NCTM) Standards

Standard 4: Mathematical Connections

- Recognize equivalent representations of the same concept
- Relate procedures in one representation to procedures in an equivalent representation
- Use and value the connections between mathematics and other disciplines

Standard 5: Algebra

- Represent situations that involve variable quantities with expressions, equations, and inequalities
- Use tables and graphs as tools to interpret expressions, equations, and inequalities
- Appreciate the power of mathematical abstraction and symbolism

Standard 6: Functions

- Model real-world phenomena with a variety of functions
- Represent and analyze relationships using tables, verbal rules, equations, and graphs
- Translate among tabular, symbolic, and graphical representations of functions
- Analyze the effects of parameter changes on the graphs of functions

Student Objectives

Students will be able to:

- Apply a formula to a problem
- Create an equation given a problem of proportion
- Relate speed and power to gears and gear ratios
- Draw conclusions from data
- Organize information and create an expository interactive multimedia or spreadsheet presentation to teach others

Materials and Resources

Printed Materials

- Butts, T., Craine, T., & Rubenstein, R. (1998). *Integrated mathematics 3*. New York: McDougall Littell.

- Walker, J. (1977). *The flying circus of physics with answers*. New York: John Wiley and Sons.

Internet Resources

- Bicycle Helmet Safety Institute
  www.helmets.org*
  Resource for helmets
- Citizens for Safe Cycling
  www.cfsc.ottawa.on.ca*
  Provides information about bicycle safety, crashes, and links to more safety-related sites
- Bicycle-Friendly Berkeley Coalition
  www.bfbc.org*
  Focuses on issues of concern to bikers in Berkeley, but may serve as a starting point for exploring possible presentation topics
- San Francisco Bicycle Coalition
  www.sfbike.org*
  Focuses on issues of concern to bikers in San Francisco, but has some good links and may serve as a starting point for exploring possible presentation topics
- Analytic Cycling
  www.analyticcycling.com*
  Technical resource that makes extensive use of advanced mathematics
- Cyber Sleuth Kids—Bicycling
  http://cybersleuth-kids.com/sleuth/Sports/Bicycling*
  Links to various biking-related sites
- Scientific and Cultural Aspects of the Bicycle
  www.science.uva.nl/research/amstel/bicycle/main.htm*
  General bicycling resource, including ideas for student projects and teaching materials
- Cybercycle
  http://library.thinkquest.org/10333/repairs/index.html*
  A site designed by students about bicycling—click on “Bicycling” for more student sites
- Exploratorium: Science of Cycling
  www.exploratorium.edu/cycling*
  Focuses on the science behind bicycling
- How Bicycles Work
  www.howstuffworks.com/bicycle.htm*
  Various articles describing the components and part of bicycles
- How fast can you go on a bicycle?
  www.science.uva.nl/research/amstel/bicycle/projects/lessons/pedal_forces*

  Lessons applying formulas, spreadsheets, and data to analyze bicycle speed

Technology—Hardware

- Computer to run software and access the Internet
- Internet connection for independent research

Technology—Software

- Spreadsheet to create final presentations
- Internet browser for independent research
- Presentation software to create final presentations