Design Challenge- Musher's Sled

Developed by: Brian Hickox, 2019 Iditarod Teacher on the Trail™

Discipline / Subject: Science, Technology, Engineering

Topic: Engineering Design Process; Distance; Time

Grade Level: 6th, 7th, 8th

Resources / References / Materials Teacher Needs:

- The Engineering Design Process (EDP)
- A stopwatch
- Materials for students to design, construct, and test (binder clips; cardboard; miscellaneous plastic casings; various textile samples; batteries; tape; straws; pipe cleaners; etc.)
- An inclined plane (outdoor aluminum slide; cardboard; plexiglass; sheet metal; etc.)
- Several (4-12) 1-ounce fishing weights

Lesson Summary: Students will use the Engineering Design Process to construct a prototype of a sled that will carry a specific weight down an inclined plane.

Standards Addressed: (Local, State, or National)

6th Grade Tech:

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution. Include potential impacts on people and the natural environment that may limit possible solutions.

ETS1-5(MA) Create visual representations of solutions to a design problem. Accurately interpret and apply scale and proportion to visual representations.

MS-ETS1-6(MA) Communicate a design solution to an intended user, including design features and limitations of the solution.

7th Grade Physical Science:

MS- PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

8th Grade Tech:

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

8th Grade Physical Science:

MS- PS2-2. Plan an investigation to provide evidence that a change in an object's motion depends on the sum of the forces on the object and the mass of the object.

6th, 7th, 8th Grade English Language Arts

CCSS. ELA-Literacy.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

Learning Objectives:

1. Students will use the Engineering Design Process to construct a prototype of a sled that will carry a weight down an inclined plane in a certain time and without breaking.

Assessment:

Method of assessment for learning:

- Group Engineering Design Process Packet/ findings
- Testing of prototype(s)

Procedural Activities

1. Organize students into groups of 3-4.
2. Review The Engineering Design Process
3. Introduce the Design Challenge and review as a class
4. Groups should use their packet as a guide to follow the steps of the EDP: Identify the Need or Problem; Research the Need or Problem; Develop Possible Solutions; Select the Best Possible Solutions; Construct a Prototype; Test and Evaluate the Solutions; Communicate the Solutions; Redesign
5. Groups/ students should record their findings and observations in their packet

Materials Students Need:

- The Engineering Design Process (EDP)
- Engineering Design Process Vocabulary
- Design Challenge- Musher's Sled
- Materials to construct prototype

Technology Utilized to Enhance Learning:

- Stopwatch

Other Information:

- Consider extending this lesson into a **MATH** lesson. Have students share their results, find the average speed of each sled (total distance/ total time), and graph their results.

Modifications for Special Learners/ Enrichment Opportunities:

Modifications:

- Provide specific daily checklists for students letting them know what step they should be working on or completed by each day.
- Break up steps into very specific tasks.
- Provide more white space for the steps (one step per page).
- Give specific students certain jobs on the design team which will allow them to show their strengths (and reduce what they struggle with).
-Have a partial sled built so students can continue the building process.

Enrichment:

-Write a research paper which discusses the history and origin of dog-sledding. Make a connection to the Iditarod and discuss the history of the Iditarod.

-Research how to make clothing more aerodynamic. Determine whether or not this would benefit mushers. Watch the interesting video, Science of Winter Olympic Games: Engineering Competition Suits.

-Research the evolution of dog-sled design(s). Discuss and/or present your findings.

Name(s):_____

Group #:_____

Block:_____

Design Challenge – Musher's Sled

Scenario

You are working with a team of engineers from an engineering company that specializes in the design and manufacturing of dog-sleds. A musher has reached out to your team because his current sled is not effectively carrying his gear. Your team's challenge is to design a sled that can effectively carry a specific weight down an inclined plane.

Design Constraints

- **Time**: You will be expected to complete this design challenge from start to finish over the course of 8-10 periods.
- **Materials:** You are permitted to use any or all of the following materials:

cardboard	duct tape
binder clips	straws
rubber bands	any choice of available textile (cotton, silk, felt, etc.)
batteries	wood
string	plastic casings and frames

- **Weight:** Your sled must be able to carry at least 4 ounces from start to finish. Additionally, your sled must be able to travel down the inclined plane and completely cross the finish line.

Photo Credit: Terrie Hanke

Directions: With your group members, follow the steps of the Engineering Design Process. Fill in the following chart with your findings.

STEP 1: Identify the Need or Problem	• What problem are you solving? • What is your team's mission? • What are the design requirements and constraints? • What determines the success of your design(s)?

STEP 2: Research the Need of Problem	• Examine what you have for resources. • Each member share his/ her knowledge and input about speed, weight, effective sleds, and the potential and beneficial uses of each available design material.

STEP 3: Develop Possible Solution(s)	• Brainstorm 3 possible solutions (even if the solution sounds too crazy) • Evaluate the possible solutions by talking to others and asking for their opinion on reasons why it was desirable or undesirable.	
SOLUTION #1	**SOLUTION #2**	**SOLUTION #3**
PROS	**PROS**	**PROS**
CONS	**CONS**	**CONS**

STEP 4: Select the Best Possible Solution	• Determine which solution best meets the original requirements (it might be a combination, or 1 of the 3 possible solutions)

STEP 5: Construct a Prototype	• Draw a detailed specification of your best solution • Build a prototype from this specification
STEP 6: Test and Evaluate the Solution	• Does it work? • Does it meet the original time constraints?

Did the sled hold at least 4 ounces? ☐ **YES** ☐ **NO**

Did the sled completely cross the finish line? ☐ **YES** ☐ **NO**

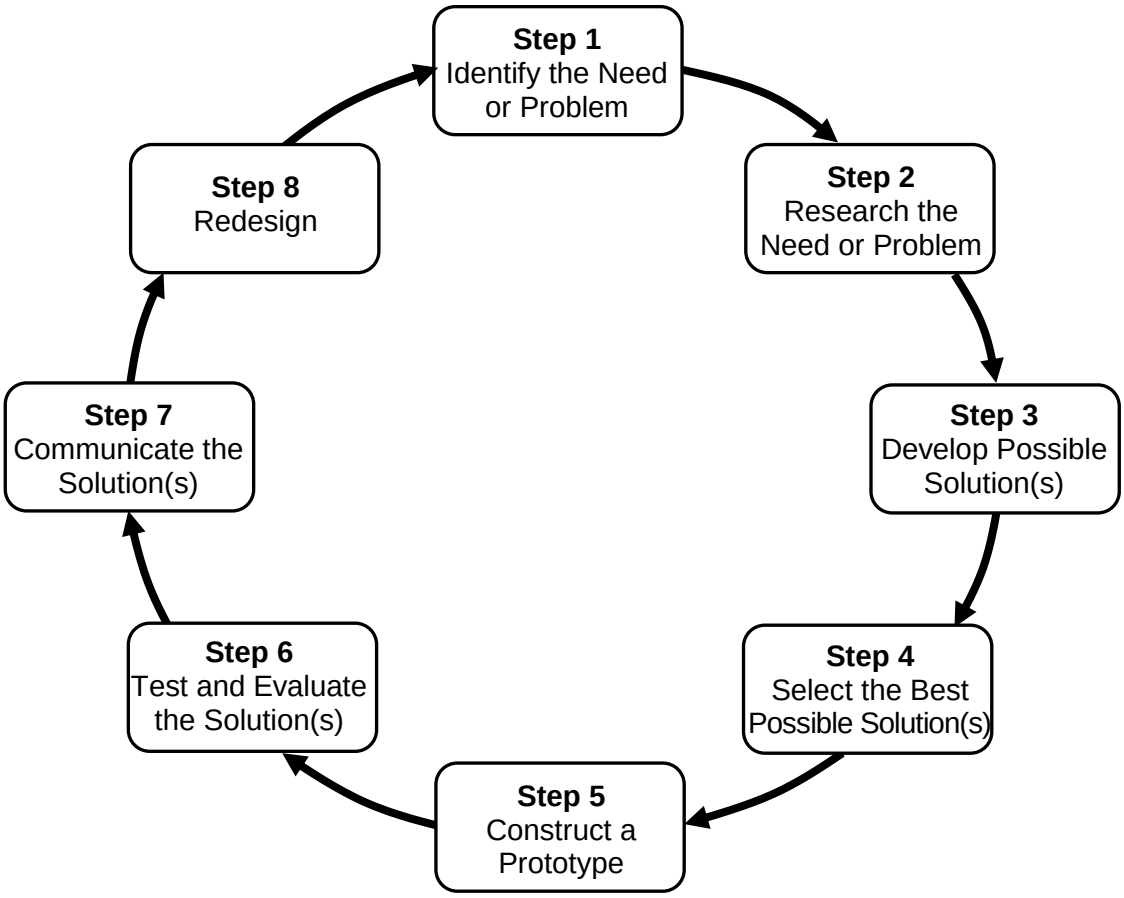
How long did it take your sled to finish? _____

How far beyond the finish line did your sled travel? _____

****For further consideration and analysis: What is the most amount of weight that your sled effectively carries across the finish line? What is the least amount of weight? How did the change in weight affect the distance?*

STEP 7: Communicate the Solution	• Make an engineering presentation that includes a discussion of how the solution best meets the needs of the initial problem, opportunity, or need. Discuss any tradeoffs and areas of improvement of the solution.
CLAIM: • What claim can you make about your sled based on your data? • Did your sled design solve the initial problem? • Was your design the best possible solution? **EVIDENCE:** • What is your evidence for your claim(s)? • Do you have enough supporting evidence? • What do you think of the quality of the evidence for the claim(s)? **REASONING:** • What is your reasoning? • Why does that evidence support the claim? • What scientific principles or concepts did you use to make sense of your data?	
STEP 8: Redesign	• Revise the solution based on information gathered during the test(s) and presentation.

The Engineering Design Process (EDP)



1. Identify the need or problem
   - Ask questions until you are clear what the problem is then write the problem down so you understand it.
2. Research the need or problem
   - See if anyone else has solved this problem (don't re-invent the wheel)
   - Examine what you have for resources (don't plan on digging a hole if you don't have any shovels)
   - Check the Internet, library, ask your teacher, etc. for information to help you solve the problem
3. Develop 3 possible solutions
   - Brainstorm 3 possible solutions (even if the solution sounds too crazy, save it for ideas)
   - Evaluate the possible solutions by talking to others and asking for their opinion on reasons why it was desirable or undesirable
4. Select the best possible solution
   - Determine which solution best meets the original requirements (it might be a combination, or one of the 3 possible solutions)
5. Construct a prototype
   - Draw a detailed specification of your best solution • Build a prototype from this specification
6. Test and evaluate the solution
   - Does it work? • Does it meet the original design constraints?
7. Communicate the solution
   - Make an engineering presentation that includes a discussion of how the solution best meets the needs of the initial problem, opportunity, or need. Discuss any tradeoffs and areas of improvement of the solution
8. Redesign
   - Revise the solution based on information gathered during the test(s) and presentation

From the Massachusetts Science and Technology / Engineering Curriculum Framework (2001)

Engineering Design Process Vocabulary

Engineering Design Process (EDP) = a method engineers use to create solutions to problems. The EDP is a problem solving process!

Criteria = desired features (e.g., you want your smart phone to fit in your pocket)

Specification = detailed requirements (e.g., you want your phone to weigh less than 1 pound).

Design = a plan used to create something (a sketch or drawing, either 2D or 3D)

Constraint = a limitation for a design (like time, money, size and weight)

Evaluate = to examine for good or bad qualities. Does the solution solve the problem?

Iteration = repeating a process. In the EDP, iteration occurs when you redesign

Prototype = a working model (should be full sized if possible)

Trade off = a compromise or sacrifice. Losing one quality to gain another quality
Example: in cars, to gain fuel economy you may have to give up engine power

From the Massachusetts Science and Technology / Engineering Curriculum Framework (2001)