Paper Bridge Design Challenge

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The story behind the problem: A suspension bridge, which was the only means of access to the village of Taveng, Cambodia had broken off due to old age. Since then, the villagers and students have had to use a bamboo raft to cross the river, posing a variety of safety hazards for them during the rainy season. This is a major problem because most of the villagers are farmers and depend heavily on selling their produce at the markets across the river. In addition, students are also greatly affected because they must travel across the river daily to get to school.

Overview

In this activity, students are posed with a problem: A rope suspension bridge has broken, separating a remote village from the mainland. The people are struggling to get their produce to the markets across the river and to get their children to school each day. The students will need to construct a bridge that will span a distance of 14 inches using limited materials *(much like the villagers will have to do)*. Their goal will be to hold as much weight *(in the form of "penny people")* as they can without the bridge collapsing. This will have to be completed in a limited amount of time since rainy season is quickly approaching.

<u>Standards</u> *- Note: This activity is designed to be a quick exercise, possibly used to introduce teamwork, the engineering design process or as a "hook" for a bigger unit. It could easily be adapted to become a more in depth design challenge, integrating numerous engineering and technology standards. Therefore, the standards will vary depending on what the teacher chooses to incorporate. A list of grade level standards that link to the activity is given below.*

MA Technology and Engineering

1.K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change that can be solved by developing or improving an object or tool.*

1.K-2-ETS1-2. Generate multiple solutions to a design problem and make a drawing (plan) to represent one or more of the solutions.*

2.K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same design problem to compare the strengths and weaknesses of how each object performs.*

Clarification Statements:

- Data can include observations and be either qualitative or quantitative.
- Examples can include how different objects insulate cold water or how different types of grocery bags perform.

3.3-5-ETS1-1. Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet.*

3.3-5-ETS1-2. Generate several possible solutions to a given design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem.*

Clarification Statement:

- Examples of design problems can include adapting a switch on a toy for children who have a motor coordination disability, designing a way to clear or collect debris or trash from a storm drain, or creating safe moveable playground equipment for a new recess game.

4.3-5-ETS1-3. Plan and carry out tests of one or more design features of a given model or prototype in which variables are controlled and failure points are considered to identify which features need to be improved. Apply the results of tests to redesign a model or prototype.*

Clarification Statement:

- Examples of design features can include materials, size, shape, and weight.

4.3-5-ETS1-5(MA). Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem.*

6.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.*

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

Clarification Statements:

- Examples of visual representations can include sketches, scaled drawings, and orthographic projections.
- Examples of scale can include ¼" = 1'0" and 1 cm = 1 m.

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

Clarification Statement:

- Examples of intended users can include students, parents, teachers, manufacturing personnel, engineers, and customers.

7.MS-ETS1-2. Evaluate competing solutions to a given design problem using a decision matrix to determine how well each meets the criteria and constraints of the problem. Use a model of each solution to evaluate how variations in one or more design features, including size, shape, weight, or cost, may affect the function or effectiveness of the solution.*
7.MS-ETS1-4. Generate and analyze data from iterative testing and modification of a proposed object, tool, or process to optimize the object, tool, or process for its intended purpose.*
7.MS-ETS1-7(MA). Construct a prototype of a solution to a given design problem.*
7.MS-ETS3-4(MA). Show how the components of a structural system work together to serve a structural function. Provide examples of physical structures and relate their design to their intended use.
Clarification Statements:

- Examples of components of a structural system could include foundation, decking, wall, and roofing.
- Explanations of function should include identification of live vs. dead loads and forces of tension, torsion, compression, and shear.
- Examples of uses include carrying loads and forces across a span (such as a bridge), providing livable space (such as a house or office building), and providing specific environmental conditions (such as a greenhouse or cold storage).

State Assessment Boundary:

- Calculations of magnitude or direction of loads or forces are not expected in state assessment.

HS-ETS3-3(MA). Explain the importance of considering both live loads and dead loads when constructing structures. Calculate the resultant force(s) for a combination of live loads and dead loads for various situations.
Clarification Statements:

- Examples of structures can include buildings, decks, and bridges.
- Examples of loads and forces include live load, dead load, total load, tension, sheer, compression, and torsion.

HS-ETS3-4(MA). Use a model to illustrate how the forces of tension, compression, torsion, and shear affect the performance of a structure. Analyze situations that involve these forces and justify the selection of materials for the given situation based on their properties.
Clarification Statements:

- Examples of structures include bridges, houses, and skyscrapers.

Examples of material properties can include elasticity, plasticity, thermal conductivity, density, and resistance to force

Science and Engineering Practices (https://ngss.nsta.org/PracticesFull.aspx)

- Asking Questions and Defining Problems
- Developing and using Models
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Arguments from Evidence
- Obtaining, Evaluating and Communicating Evidence

Lesson Timeline *(One 45 min class period)*

Duration	Activity	Instructions
5 mins	Introduction	Read "The Problem" to the class and put the students into small groups of 3-4.
10 mins	Design challenge	Give the students 10 mins to design and construct their bridge with the given materials.
10 mins	Group Share	The students should share their design solutions with the class *(allow time for comments, questions or feedback).*
7 mins	Redesign	Students should redesign and retest their solutions.
10 mins	Group Share	The students should share their final design solutions (allow time for comments, questions or feedback).

Learning Targets

- **Day 1** - I can utilize the engineering design process to design, test and redesign a prototype that will solve a problem.
- **Day 1** - I can present my solution to other students and accept feedback
- **Day 1** - I can provide feedback to other students on their design solution.

Vocabulary

Criteria – the requirements that must be met by the project
Constraint – a limitation or condition that must be satisfied by a design. *(common constraints include time, cost, and materials)*
Prototype – the first model of the solution

Materials

- Student Design Handout
- 2 pieces of Copy Paper per group
- 6 inches of tape per group
- 50 pennies per group *(penny people)*
- Scissors
- Rulers

Name: ____ Date: __________

Paper Bridge Design Challenge

STUDENT DESIGN

THE PROBLEM: A rope suspension bridge has broken, separating a remote island village from the main island. The villagers are struggling to get their produce to the markets across the river and to get their children to school each day. Time is of the essence since rainy season is quickly approaching.

THE CHALLENGE: You will need to construct a bridge that will span a distance using limited materials *(much like the villagers will have to do)*. Your goal will be to design the bridge to hold as much weight as possible without the bridge collapsing. This must be completed in a limited amount of time.

Criteria:

- The bridge must span a distance of 14 inches *(span can be between two desks or two chairs)*
- The bridge must hold as many "penny people" as possible without collapsing

Constraints:

- The only materials you have are two pieces of copy paper, 6 inches of tape, scissors and rulers
- You have 10 mins to complete the task

Step 1 – Brainstorm building ideas with your group.
Step 2 – Build and test your design
Step 3 – Share your results with the class and listen to others. How well did your design perform? What did other groups do that you can learn from?

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Step 4 – Discuss possible redesign options *(to improve strength or stability)*. Redesign, rebuild and retest.
Step 5 – Share your results with the class and listen to others. How well did your final design perform? What did other groups do that you can learn from?

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