Building Bridges:
A STEMtastic Challenge for Guinea Pig Pals

Pet:	Class:
Guinea pig	**3-5**

Brief Overview:
In this lesson, students design and construct miniature bridges using straws, cardboard, or other materials, testing their strength and stability under guinea pig "traffic." They explore concepts of load-bearing forces and bridge design principles. *This lesson is easy to adapt for other grades and pets.*

Essential Question
How can we use science and engineering to design and build bridges strong enough for our guinea pig friends?

Lesson Breakdown
Lesson 1: Bridge Brainstorming and Research
Lesson 2: Building Bridges
Lesson 3: Bridge Testing and Data Collection

Subjects
- ☑ Science
- ☑ ELA
- ☑ Math
- ☑ STEM
- ☐ Art
- ☐ Other

Stem Connections
Science: physics of load bearing forces
Technology: 3d printing (optional)
Engineering: creation of bridges
Math: measuring, weighing, budgeting

Performance Expectations/ Standards
NGSS
3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

CCSS ELA Alignment:
RI.3.7: Use information from multiple print and digital sources, demonstrating understanding of a topic.
W.3.7: Conduct short research projects that answer a question and support the findings with evidence.
SL.3.1: Engage effectively in classroom discussions by asking and answering questions.
L.3.1: Demonstrate command of conventions of standard English grammar and usage when writing or speaking.

CCSS Math Alignment:
3.MD.A.1: Measure and record lengths with rulers to the nearest whole unit.
3.MD.A.2: Measure and record mass with balances to the nearest whole gram.
5.G.A.1: Draw two-dimensional representations of three-dimensional figures from different perspectives.

I CAN statements
- define the problem we are trying to solve.
- brainstorm and design a bridge to solve the problem.
- build my bridge using safe and appropriate materials.
- test my bridge and collect data.
- analyze the data and evaluate my bridge's success.
- communicate my findings and design to others**.**

Materials

- The Wonderful World of Bridges
- Building Bridges Student Worksheet
- Cardboard, straws, glue, popsicle sticks, skewers, tape, paper clips, soil;, marshmallows, sugar cubes, etc.

Teacher Background

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Bridges are not just engineering marvels; they are cultural symbols, connecting communities and shaping landscapes. The scientific principles behind their construction offer a captivating glimpse into the laws of physics and the power of human ingenuity. In this article, we describe three common types of bridges.

1. Beam Bridges: The simplest and most ancient form, beam bridges are essentially horizontal beams supported at each end by abutments. These workhorses of the bridge world rely on their inherent strength to carry loads, making them ideal for shorter spans and lighter traffic. Popular materials include steel, concrete, and even wood – the humble log bridge being a timeless example.

2. Suspension Bridges: These giants rely on a network of cables suspended from towering pylons to carry the weight of the bridge deck. The cables, often made of high-strength steel, form a catenary curve, distributing the load efficiently across the span. The Golden Gate Bridge, with its fiery orange glow and imposing towers, is a breathtaking example of this technology.

3.Arch Bridges: These graceful curves stand in defiance of gravity, transferring the weight of the bridge downward into the ground through their arched structure. Made of stone, concrete, or steel, arch bridges often feature stunning visual symmetry and can withstand immense loads. The Pont du Gard, a Roman architectural marvel, and the modern Millau Viaduct, soaring over the Tarn Valley in France, exemplify the enduring beauty and functionality of this type.

Lesson 1: Bridge Brainstorming and Research		
Time	**Materials**	**Activity**
5 mins		Conduct a class discussion about what makes a good bridge (strong, stable, etc.) and record these on the board.
20 mins	The Wonderful World of Bridges	Share with students the presentation about the different types of bridges
5 mins	Building Bridges Student Worksheet	Introduce the students to the challenge: How can we use science and engineering to design and build bridges strong enough for our guinea pig friends?
15 mins	Building Bridges Student Worksheet	In their small groups, have the students begin brainstorming their designs. Remind them that they have a budget of $25,

Lesson 2: Bridge Building		
Time	**Materials**	**Activity**
10 ins	Building Bridges Student Worksheet	Students may need more planning time.
35 mins	Building Bridges Student Worksheet Cardboard, straws, glue, popsicle sticks, skewers, tape, paper clips, soil;, marshmallows, sugar cubes, etc.	Provide students with various materials like cardboard, straws, tape, glue, and popsicle sticks, etc. and let them start building their bridges based on their designs. Encourage collaborative teamwork and problem-solving

Lesson 3: Bridge Testing and Data Collection		
Time	**Materials**	**Activity**
25 mins		Weigh your guinea pig. Have the students add weight to the bridge, small amounts at a time. The goal is to reach the same amount of weight (Or more!) as the guinea pig. *It is not recommended to test the bridges with the actual guinea pig for safety reasons.*
10 mins		Discuss the results of the bridge testing. Ask students to analyze the data and identify which bridges were successful and why.
10 mins		Discuss the engineering principles learned throughout the activity, like load-bearing forces and stability. Reflect on the importance of collaboration, problem-solving, and testing in engineering If time permits, allow the students to redesign their bridges. Repeat the testing process with the improved bridges.

Differentiation
For students who need additional support:

- Provide pre-made templates or simpler materials for younger students.
- Allow students with individual needs to contribute in other ways, like research, data recording, or presenting their findings.

For students who need additional challenges:

- Offer challenges for advanced students, like increasing the weight limit or testing different types of forces on the bridges.

Assessment				
Category	**4 Points (Exemplary)**	**3 Points (Proficient)**	**2 Points (Developing)**	**1 Point (Emerging)**
Design and Construction:	Innovative and well-designed bridge, utilizing appropriate materials and construction techniques for both superstructure and substructure.	Bridge demonstrates creativity and functionality, but may have minor flaws in material choice or construction.	Bridge design is basic and may show inconsistencies or flaws in material selection or construction.	Design lacks creativity and functionality, with significant flaws in material choice or construction.
Testing and Analysis:	Thorough and well-defined testing method, leading to insightful data analysis and conclusions.	Testing method is appropriate but lacks detail or analysis of results is incomplete.	Testing method is rudimentary or unclear, data analysis is limited or absent.	Testing is absent or ineffective, no data analysis is provided.
Teamwork and Reflection:	Strong evidence of collaborative problem-solving and effective communication. Reflection identifies challenges and lessons learned with clarity.	Teamwork is evident, but communication or problem-solving could be improved. Reflection is present but may lack detail or insight.	Teamwork and communication are limited, challenges and lessons learned are not clearly identified.	Teamwork and reflection are absent or minimal.

Extension

- Build larger bridges for other classroom pets or stuffed animals.
- Research real-world bridge disasters and discuss factors that can weaken bridges.
- Design and build miniature cities complete with bridges, roads, and buildings.
- Create a children's book about guinea pigs who build bridges.