STEM Stories: Twenty-One Elephants and Still Standing Lesson Plan

STEM Career Connections: Civil Engineering, Chemical Engineering, Architecture and Construction

STEM Disciplines: Science, Technology, Engineering and Mathematics

Non-STEM Disciplines: English Language Arts

Design Challenge Problem/Scenario:

Phineas T. Barnum marched his elephants across the Brooklyn Bridge to prove the bridge was safe. Since the bridge held for 21 elephants, everyone now wants to take the bridge. The city needs to build another bridge to hold all the people who want to cross the river. The river is wider where the new bridge will go, so it needs to be longer than the first bridge.

Engineering Design Challenge:

Your team's challenge is to design and build a bridge according to directions and then make the bridge longer to cross the river where it is wider.

Essential Question Students Investigate:

What types of bridges exist and how can they be modified to be longer. How does the length of the bridge affect how much weight the bridge can hold?

Enduring Understandings:

- Using the engineering design process when approaching problems results in unique solutions.
- Collaboration and following the engineering design process lead to more creative and effective solutions to problems.
- The concepts of strength of materials and structural integrity are important for this problem. The design structure should hold weight without breaking or deflecting beyond safe limits.

English Language Arts Standards:

- RL.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- RL.3.4 Determine the meaning of words and phrases as they are used in a text, distinguishing literal from non-literal language.
- W.3.3 Write narratives to develop real or imagined experiences or events using effective technique, descriptive details and clear event sequences.
- SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.
- SL.3.6 Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification.

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Science Standards:

Science Inquiry and Applications, Technological and Engineering Design
During the years of PreK to grade 4, all students must develop the ability to:

- Plan and conduct simple investigations
- Employ simple equipment and tools to gather data and extend the senses
- Communicate about observations, investigations and explanations
- Review and ask questions about the observations and explanations of others
- Identify problems and potential technological/engineering solutions
- Understand the design process, role of troubleshooting

Grade 1: PHYSICAL SCIENCE: Motion and Materials

- Objects can be moved in a variety of ways, such as straight, zigzag, circular, and back and forth.

Grade 2: PHYSICAL SCIENCE: Changes in Motion

- Forces change the motion of an object.

Grade 5: PHYSICAL SCIENCE: Light, Sound, and Motion

- The amount of change in movement of an object is based on the mass of the object and the amount of force exerted.

NOTE: This activity uses the words mass and weight to describe objects. These two words are often used interchangeably in everyday language. In science they have different meanings. Mass is the amount of matter an object has and is measured in grams or kilograms. An object's mass will remain the same wherever it is located, even in outer space. An object's weight is the force of gravity that is being exerted on the object and is measured in Newtons or lbs. Near the surface of the Earth, an object's weight can be found by multiplying the object's mass by 9.8 N/kg. On the moon, objects have the same mass, but their weight is six times smaller since the force of gravity due to the moon is six times smaller. Try to always use the word mass with grams or kilograms, and the word weight with lbs. In this lesson, the students will place grams on their bridge to determine the mass it can hold.

Mathematics Standards:

- Represent and interpret data. CCSS.MATH.CONTENT.3.MD.B.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units--whole numbers, halves, or quarters.
- Use place value understanding and properties of operations to perform multi-digit arithmetic. CCSS.MATH.CONTENT.3.NBT.A.2 Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction.
- Use place value understanding and properties of operations to perform multi-digit arithmetic. CCSS.MATH.CONTENT.3.NBT.A.2 Multiply one-digit whole numbers by multiplies of 10 in the range 10-90 (e.g., 9 x 80, 5 x 60) using strategies based on place value and properties of operations.

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- Represent and solve problems involving multiplication and division. CCSS.MATH.CONTENT.3.OA.A.1 Interpret products of whole numbers, e.g., interpret 5 x 7 as the total number of objects in 5 groups of 7 objects each.
- Represent and solve problems involving multiplication and division. CCSS.MATH.CONTENT.3.OA.A.1 Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.
- Multiply and divide within 100. CCSS.MATH.CONTENT.3.OA.C.7 Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 x 5 = 40, one knows 40 ÷ 5 = 8) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers.

Materials List:

Material	Quantity per Team	✓	Quantity per Kit	✓
Twenty-One Elephants and Still Standing by April Jones Prince	~		3	
K'Nex Education Bridges Kits	1		8	
Masses for Testing	~		1 set	
Masking Tape	~		20 ft	
Paper Plates	3		24	

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Activity 1

Introduction: 15 minutes

- Sit in a chair and gather the students on the floor around you so they can all see the book.
- Remind the students of the full scope of the Engineering Challenge (Activity 1, Activity 2, Activity 3, etc.).
- Introduce *Twenty-One Elephants and Still Standing* by April Jones Prince. Show them the cover of the book and ask them what they think the book might be about. Take a picture walk through the book to identify the main events at the beginning, middle, and end of the story.

Pre-Reading: 10 minutes

- Post the list of words and distribute individual lists to each student (these can be pasted into the STEM notebook, Entry #X, Date). Place students into pairs, and ask them to work together to circle the words they think will be included in the story, and put a line through the words they think will not be included in the story. Remind them to use what they know about the story already, including that it is about the building of the Brooklyn Bridge.
- Invite students to share the words they circled and crossed out on the displayed word list. Discuss their contributions, including why they think certain words should be circled or crossed out. Try to come to a class consensus, and invite respectful debate about the choices. Encourage students to use evidence from the text (the picture walk) and their background knowledge to support their choices. There are no right or wrong answers in this discussion.

Read Aloud: 20 minutes

- Read the book aloud to the students. When you come to one of the words on the list, place a star next to it (or other mark) on the displayed word list.
- After reading the book, ask the students to revisit the word list in their Notebooks, using a different color to change the markings on the words based on which words actually appeared in the story.

Post Reading: 15 minutes

- Assign pairs a word from the list that was used in the story. First, they should write the word in big, colorful letters on a large piece of paper. Then, they should act out the meaning of the word in a “tableau” style. They will act as “statues” to act out the word in a single pose, not in a full skit. For example, for the word, “delight”, pairs might stand with smiles on their faces, hands on their cheeks, looking at a pretend baby - they should act “delighted”.
- Each pair should present their word to the class. The teacher should hold up their word card when they do this. If time does not allow for pairs to present, you can take pictures of the tableaus and use them in subsequent lessons to review the vocabulary words.

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Wrap Up: 5 minutes

Review what was learned during today's session.

- Invite a retelling of the book by asking students to share what happened first, second, third and so on in the story.
- Remind the students that next time they will hear more about the Engineering Design Challenge.
- Encourage students to look for bridges they travel over or see everyday.

Activity 2

Introduction: 10 minutes

- Picture walk through the story and have students explain what happens (main idea).
- Ask students if they know of any bridges that they cross often or have been on.
- Relate the story to the design challenge.
    - "In the story a bridge was built to connect Brooklyn to Manhattan. For our design challenge you will be thinking of how to build a bridge that has to cross a wider river, which means the bridge will have to be longer. We will learn more about this later."

Quick Write: 15 minutes

- For the *Quick Write*, provide students with an image of the Brooklyn Bridge. Invite them to embellish the image with people, elephants, or other elements from the story. Paste the completed images into the STEM Notebooks (Entry #X, Date).
- Next, ask the students to "caption" their image. They should write a one to five sentence caption (adjust for differentiation) describing what is happening in their picture. Remind them to ground their drawings and captions in evidence from the text. Provide a model.
- Invite students to share their images and captions with the class.

Application: 20 minutes

- Display slide 1 of the PowerPoint.
- Slide 2: Complete the journal entry for Day 1.
- Slide 3: Present the Engineering Design Problem and Challenge.
    - Design Challenge Problem: Phineas T. Barnum marched his elephants across the Brooklyn Bridge to prove the bridge was safe. Since the bridge held for 21 elephants, now everyone wants to take the bridge. The city needs to build another bridge to hold all the people who want to cross the river. The river is wider where the new bridge will go, so it needs to be longer than the first bridge.
    - Engineering Design Challenge: Your team's challenge is to build a bridge according to directions and then make the bridge longer to cross a wider section of the river.
- Slide 4: Explain or share the Design Goals.
    - Design a bridge using K'Nex Education- Introduction to Structures: Bridges.

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    - The bridge must be 8 K'Nex panels long.
    - The bridge should hold the most weight possible.
- Slide 5: Introduce the resources/materials available.
    - Students will use K'Nex panels, rods and connectors.
- Slide 6: Explain the design testing procedures.
    - Move two tables about 18 inches apart and place the bridge on top of the tables to connect them.
    - Make sure nothing is underneath the bridge or tables.
    - Add testing masses to the top of the bridge until it collapses or is no longer safe to use.
    - Record how much mass the bridge held.
- Slide 7: Explain the Engineering Design Process
- Slide 8: Have the students complete the "Ask" step of the Engineering Design Process.
    - Give students the Engineering Design Process Graphic Organizer STEM Challenge handout and the Twenty-One Elephants: Engineering Design Process student handout.
    - Ask the students to notice that the word Ask is in one of the circles of the Engineering Design Process both on the PowerPoint and on the Twenty-One Elephants: Engineering Design Process student handout.
    - Share with students that we will be exploring more about bridges to answer the Ask questions displayed on the slide.
        - Who usually works on bridges?
        - What bridges already exist?
        - Which bridges are strongest and best for going over a river?
        - Why do we need bridges?
    - Students should write the question they want to explore more about on their STEM Challenge handout.
    - Walk around as the students complete the Ask step of the Engineering Design Process and query them about how they will research their question.
- Slide 9: Have students do the River Challenge.
    - Problem: You have just arrived at a river. You want to cross the river, but there is no bridge close by. You find large rocks nearby and will work with your team to try to get everyone across the river without getting wet.
      Rules:
      If anyone on the team steps in the river, everyone starts over.
      You can only step on the rocks.
      Only one rock can be moved at a time.
      You cannot slide the rocks in the river.
      You can only hold a maximum of 2 rocks in your hands at one time.
    - In a large open area, place two parallel lines of tape on the floor about 20-30 feet apart. This will represent the "river."
        - Give each student something to represent the rocks, like one paper plate, one piece of paper, one piece of cardboard, etc.
        - Students all begin on one side of the river and are given one rock (paper plate) to cross the river. Let students decide what to do on their own and provide clues if necessary. (The ideal method is for the first

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student to place a plate in the river and step on top of the plate. Then student 2 hands student 1 their plate, and student 1 places student 2's plate in front of them and moves forward, allowing student 2 to move onto the plate previously occupied by student 1. Student 3 then hands their plate to student 2 who then hands the plate to student 1 who places student 3's plate in front of them and moves forward, allowing student 2 to move onto the plate previously occupied by student 1 and student 3 to move onto the plate previously occupied by student 2. Students keep passing their plates forward and moving onto the next plate- see video)

- Possible modification: Divide students into teams and have them race to see which team can cross the river first.

Wrap Up: 5 minutes

Review what was learned during today's session.

- Invite a retelling of the book by asking students to share what happened first, second, third, and so on in the story.
- Remind the students of the Engineering Design Challenge.
- Preview the next session by explaining to students that they will continue the Engineering Design Process by building a bridge with K'Nex.
- Encourage students to look for bridges they travel over or see everyday.

Activity 3

Set-Up

- Designate space for displaying and gathering available materials.
- Designate space for each team to collaborate and build their design ideas.
- Make sure all students will be able to see the presentation.

Introduction: 5 minutes

- Remind the students that during the previous session they read and discussed the book *Twenty-One Elephants and Still Standing* by April Jones Prince and were presented with a Design Challenge Problem and Engineering Design Challenge. Generate a discussion about the Design Challenge Problem and Engineering Design Challenge.
- Slide 10: Have students complete the journal prompt and encourage them to share their answers with the class.
    - Why do we need bridges?
    - What problems do they solve?
    - Write a story about a time a bridge solved a problem.

Engineering Design Process, Ask, Imagine, Plan, and Create: 60 minutes

- Slide 11: Remind students they are still in the Ask section of the engineering design process trying to learn more about bridges. Today they will build different types of bridges and later test them to see how strong they are.

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- Slide 12: Display the different types of bridges. Have students think about which one they want to build. You can either allow students to pick which K'Nex bridge they would like to create or assign pairs of students to build a specific K'Nex bridge according to the K'Nex instructions.
- Slide 13: Bridge A is the most difficult to build while bridges B and C are the easiest. The other bridges in the instruction booklet will be more difficult to test because they have middle supports. Try to have each group build a different bridge so they can compare how the varied designs affect the strength of the bridge.
- Distribute the K'Nex bridge kits and help students find the bridge they want to build in the instructional booklet.
- While students are building, asking probing questions like:
    - Why did you want to build this bridge?
    - Have you ever seen a bridge like this one?
    - Do you think the instructions are easy to follow?

Wrap Up: 5 minutes

- Ask students to place their handouts and materials in a safe location and to clean up their area.
- Distribute a parent letter to each student.

Activity 4

Set-Up:

- Designate space for testing. Align tables about 18 inches distance apart and make sure all students are gathered around to see.
- Designate space for each team to collaborate and build their design ideas.
- Make sure all students will be able to see the presentation.

Introduction: 5 minutes

- Show the students the book, *Twenty-One Elephants and Still Standing* by April Jones Prince, and ask them to raise their hands and offer a one-sentence summary of the book. Invite as many one-sentence summaries as time allows. Alternatively, ask the students to turn to a partner and tell a one-sentence summary of the book. Remind students that they are working on designing their own bridge to help more people cross a river.
- Help teams of students locate their handouts and materials.
- Remind the students that during the previous session they built a bridge according to directions.
- Today, students are going to test the bridges they designed the previous session.

Engineering Design Process, Ask - Discovering: 15 minutes

- Distribute the Name the Bridge handout. Have students complete the handout by looking in the K'Nex education Bridges Instruction Manual to match the name of the bridge to the picture on the handout. Have them write the name of the bridge on the line next to the picture.

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Engineering Design Process, Ask - Testing: 30 minutes

- Slide 14: Explain the design testing procedures again.
- Distribute the Twenty-One Elephants and Still Standing: Test and Improve Your Bridge handout. Inform students they will need to record how many of each mass their bridge holds.
    - Have students carefully place masses in the middle of the bridge until the bridge breaks.
        - Slide 15: Show the example of question 1 (bridge drawing with masses)
        - Slide 16: Show the example of question 2 (counting the masses)
        - Have students try to complete part b of question 2 on their own.
        - At some point, ask students to explain how they can use multiplication to combine numbers when the same masses are used more than once.
- Ask the students questions while they are testing:
    - What parts broke and why?
    - How would you change it?
    - What worked and what did not?
- Celebrate each team's design by having the class applaud for that team after that team shares their design.
- If time allows, have students fix their bridge and test multiple times, placing the weights at different places on the bridge deck.

Determine the Cost of Your Bridge: 15-20 minutes

- Give each student a Twenty-One Elephants and Still Standing: Determine the Cost of Your Bridge handout. Students will count the number of K'Nex panels, rods, and connectors that their team used to build their bridge. They will record these numbers in the table on their handout and determine the cost of the items using the prices shown on the handout.
- If time permits, students share the cost of their bridge with the entire class.

Wrap Up: 10 minutes

- Ask students to place their handouts and materials in a safe location and clean up their area.
- Discuss text-to-self, text-to-text, and text-to-world connections with the students. Put the Text Connections handout on the overhead or Elmo machine so all students can see it and explain each type of connection.
- If time allows, read the story*, Twenty-One Elephants and Still Standing,* again. As you read, ask the students to make text-to-self, text-to-text, or text-to-world connections between what they hear in the story and the STEM challenge. Ask them to keep track of their connections using tally marks for each connection on a blank copy of the handout, which can be pasted into the STEM journal as an additional entry.
- Stop periodically throughout the story to share your own connections as a model, then invite students to share their connections. Remind them of the importance of

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using “textual evidence” to make their connections. Ask, “What sentence or picture in the story helped you make that connection?”.
- (Optional Writing Activity) Ask the students to write a one paragraph summary of their connections to the book and the STEM challenge in their STEM notebooks.
- Slide 17: Conclude by discussing the questions on the slide.
- Distribute the parent letter to each student.

Optional Pre-Engagement Activity

Set-Up:
- All students will need a computer with internet access.

Introduction: 20 minutes
- Show national bridges or local bridges to the students and give a short history of each.
- Ask students:
  - What do you think the bridge is used for?
  - Make some observations about the bridge (short, tall, long, colorful, etc.).

Research: 15 minutes
- Inform students that they will be picking a bridge and researching about it before the next engineering design challenge - building a bridge.
- Introduce students to using a search engine in a web browser to find information about the bridge they chose.
- Show students how to create a google document or google slide where they will put their research information.
  - Have students: a) cut and paste an image of the bridge they want to research into their document or slide, b) write a paragraph about their bridge, and then c) type their completed paragraph into their document below the image of the bridge.
  - Show students how to share their document or slide with the instructor.
- Students can also research the following:
  - How much does an average elephant weigh? [We use the word weigh here because students will find on the Internet that the average weight of an elephant is often recorded as 2.5 to 7 tons, or 5,000 lbs. to 14,000 lbs.] Using what you found on the Internet for the average weight of an elephant, how much weight was on the Brooklyn Bridge when the twenty-one P. T. Barnum circus elephants crossed it?
  - How long is the Brooklyn Bridge? What is the widest span of the original Brooklyn Bridge? What is the widest span of the current Brooklyn Bridge?

Presentation:
- Open the shared documents or slides and project them for all to see with a projector or Smartboard.
- Invite students to present their research document/slides to the class by sharing what they learned about their bridge.

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