Grade 2

Challenge 1: Bring Home the Bacon

Key Question

What can we do to make travel over the river quick and safe?

Problem

Baconville is across the river from Nobacon. For years, the citizens of Nobacon have crossed a wide, deep river with dangerously strong currents, and sometimes rising water, by boat to bring home the bacon. They are looking for a faster and safer way to bring larger amounts of bacon to their town. Baconville has decided to help meet their needs by building a bridge that trucks can safely drive across to deliver bacon.

Design Challenge

Help bring bacon to Nobacon! As a team of civil engineers, design and build a bridge that spans at least 25 cm and will support the greatest load possible. Your team should be prepared to justify and explain your design and why you chose certain materials.

Teacher Notes

Student teams will use their knowledge of the physical properties of materials (TEKS K.5A and 1.5A) and what they learn through research about bridges to design and build a bridge that meets the criteria.

Second grade students may have limited experiences and knowledge of bridges. They may believe that bridges are not flexible and do not move when outside forces act on them. Students may think that simply placing a flat structure between two supports will provide a sufficient bridge.

Through research, students may learn that bridges balance forces to hold up a load between supports. Forces that act on bridges are called compression (push or squeeze, inward) and tension (pull or stretch, outward) forces.

Engineers build bridges. Civil engineers build structures, such as bridges and buildings, and ensure they are safe and stable. They also work with other engineers and architects to make sure the structures they create are pleasing to the eye and do not disrupt or damage the area in which they are built.

Materials

For the teacher

- images or videos of different types of bridges
- balance and known masses (300 grams for testing bridges)
- 2 chairs, tables, or a large plastic tub
- chart paper and marker
- calculator (optional)

From the Advance Preparation section

- truck
- pre-measured objects
- river

For each team

For the activity from the Engage section

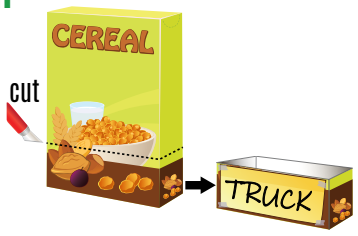
- six 3" × 5" index cards
- scissors (optional)
- six 3 or 5 oz. plastic or paper cups

For bridge building

- Team Budget Page, one per team
- craft sticks, large and small
- copy paper
- ruler
- scissors
- straws
- tape, 30 cm per team
- Materials and Price List, one per team

Advance Preparation

Make a Truck



Create a truck by cutting off the bottom 8–10 cm of a large cereal box. Alternatively, you may collect a toy truck or plastic container that is similar in size and shape to the bottom of a cereal box and has a bed to hold the pre-measured objects and known masses during testing. For the purpose of this challenge, the truck does not need wheels.

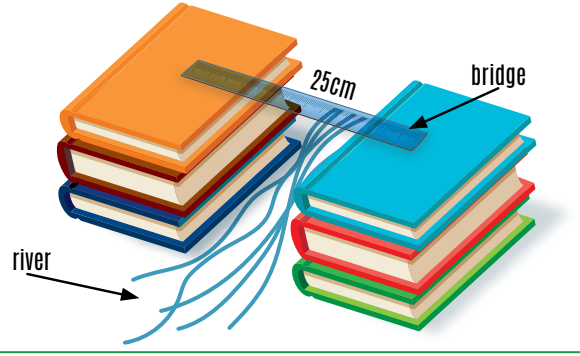
Pre-measured Objects

To simplify the testing process, fill three or four travel-size shampoo bottles, or other small containers, with sand or beans. Measure the mass of each container and record it on its side. During the test process, place these pre-measured objects into the truck to serve as the starting "load." Then allow student teams to add known masses to fill the truck to test their bridges.

Create a River

Create a river with riverbanks using one of the following three options:

- Option 1: Stack two sets of books or shoebox lids approximately 7.5–10 cm high and 25 cm apart.
- Option 2: Place two tables or chairs 25 cm apart.
- Option 3: Use a large plastic tub with an opening that is at least 25 cm across. You may choose to place chairs or tables on either side of the box to help support each bridge and represent each town.



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Advance Preparation continued

Use your Internet browser to search for videos using the terms such as "bridges for kids" and/or "bridges." Conduct this search prior to class to verify the content is appropriate for the class and the challenge.

Suggested Time Frame

- Ask, Imagine, and Plan: Allow teams 1–1.5 hours which may be broken down over a few days. This should include time for students to
  - research bridges and bridge construction **(not more than 45 minutes)**
  - explore the materials **(about 5 minutes)**
  - sketch their bridges independently **(about 10 minutes)**
  - reach a team consensus on final bridge design **(about 10–15 minutes)**
- Create, Test, and Improve: Allow **45–60 minutes** for teams to build, test, and improve their bridges.
- Evaluate: **5–10 minutes** for each team to test and present their bridge to the class

The amount of time needed for this challenge may vary depending on your students' research skills and findings.

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Texas Essential Knowledge and Skills (TEKS) for Science Connections

Science Concepts

2(5) Matter and energy. The student knows that matter has physical properties and those properties determine how it is described, classified, changed, and used.

(A) The student is expected to classify matter by physical properties, including relative temperature, texture, flexibility, and whether material is a solid or liquid;

(C) The student is expected to demonstrate that things can be done to materials such as cutting, folding, sanding, and melting to change their physical properties; and

(D) The student is expected to combine materials that when put together can do things that they cannot do by themselves such as building a tower or a bridge and justify the selection of those materials based on their physical properties.

Science Process Skills

2(2) Scientific investigation and reasoning. The student develops abilities necessary to do scientific inquiry in classroom and outdoor investigations.

(E) The student is expected to communicate observations and justify explanations using student-generated data from simple descriptive investigations; and

(F) The student is expected to compare results of investigations with what students and scientists know about the world.

2(4) Scientific investigation and reasoning. The student uses age-appropriate tools and models to investigate the natural world.

(B) The student is expected to measure and compare organisms and objects.

English Language Proficiency Standards (ELPS)

3(E) Cross-curricular second language acquisition/speaking. The student is expected to share information in cooperative learning interactions.

TEACHER GUIDE

ENGAGE

- Divide the class into teams of 3–4 students and assign each team a place to work.
- Distribute six index cards and six cups to each team.
- Instruct student teams to use the provided materials to build a freestanding bridge. The longest bridge built using the fewest materials will be the winner.
- Give teams 1 minute to plan and 3 minutes to build.
- Allow each team to share about and measure their bridge.
- Introduce the problem by discussing the bridges the teams just built, what the students know about bridges, the materials used to build bridges, and the ways we use bridges.

FACILITATION QUESTIONS:

- How were your bridges similar? How were your bridges different?
- Did some bridges work better than others? What construction choices were effective? What construction choices were not effective?
- What does a bridge need to do? *Bridges need to span specific distances and support the load that will cross it, including pedestrians, trains, vehicles, or a combination of people and vehicles.*

ENGINEERING DESIGN PROCESS (EDP)

ASK

- Distribute a design challenge card to each team or read the design challenge, criteria, and constraints to the class.
- Display the river and truck that will be used during the Evaluate portion of the challenge. Ask one student to measure the width of the "river" and report it to the class. Ask a different student to measure the length and width of the "truck" and report those measurements to the class. Teams should record this information in their Engineering Design Notebooks for use as they plan.
- Create a "Know/Need to Know" T-chart and facilitate a class discussion. Ask questions to ensure all students understand the challenge.

FACILITATION QUESTIONS:

- What can we do to make travel over the river quick and safe?
- What are the criteria? What are the constraints?
- What do you need to know in order to solve this problem?

SENTENCE STEMS:

- The problem is . . .
- The challenge is . . .
- To meet the criteria, the design needs to . . .
- The constraints are . . .
- To solve this problem, I need to know or learn more about . . .
- Others have tried . . .
- I would solve the problem by . . .

Challenge 1: Bring Home the Bacon

TEACHER GUIDE | ENGINEERING DESIGN PROCESS (EDP)

IMAGINE

- Guide the research process. You may provide research materials (access to the Internet or experts, artifacts, books, and magazines) to teams or lead all students through the research process.
- Provide books and magazines with pictures for reference.
- Define vocabulary and model techniques for research and note-taking as you facilitate the research process.
- Allow students to observe and explore the materials available for bridge building.

  Note: Do not give materials to teams at this time.

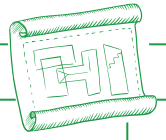
SUGGESTED RESEARCH TOPICS:

- bridge design and construction
- how others have addressed the same problem in the past

FACILITATION QUESTIONS:

- What are the important parts of a bridge?
- How can you ensure the bridge will span the river?
- How can you ensure the bridge will support the load?
- How can you ensure the bridge will not fall or collapse?

PLAN



Independent Planning

- After they have finished their research, instruct students to create a sketch of their individual ideas. Remind students to include details such as labels, measurements, and explanations of how each part functions.
- Instruct students to think about one of the following sentence stems and complete the sentence.
  - I think my team could solve this problem by . . .
  - My idea for solving this problem . . .
  - Based on my research and understanding, I think we should . . .

Team Planning

- Facilitate consensus building and planning, encourage engagement, and support detailed sketching.
- Provide a clean sheet of paper for each team to record its final plan.
- Provide feedback to student teams on their final design and plans.
- Assist teams in managing roles and help team members understand their responsibilities within the challenge.
- Allow Materials/Budget Managers to collect the materials for their teams.
- Observe teams to assess their collaboration, creativity, critical thinking, communication skills, and application of content knowledge.

SUGGESTED ROLES:

- Project/Quality Control Manager
- Construction Manager
- Materials/Budget Manager
- Creative Design Manager

FACILITATION QUESTIONS:

- What materials do you have available to solve this problem?
- Which of the materials would be best for building a bridge?
- What materials do you need?
- Which idea or combination of ideas will you use?

SENTENCE STEMS:

- Our plan for solving this problem is . . .
- We will need the following materials . . .
- The steps we will take are . . .
- Our role assignments are . . .

TEACHER GUIDE | ENGINEERING DESIGN PROCESS (EDP)

CREATE/TEST/IMPROVE

- Allow teams to work together to create, test, redesign, and retest their prototypes. You may choose to allow teams to test their bridges against one or both of the following conditions:
  - Does the bridge span the river?
  - Does the truck fit on the bridge?

  To be fair, inform all teams of what can and cannot be tested during this phase.
- Remind students to record what happens each time they test and redesign, noting their successes and failures along the way.
- Manage materials and ensure students follow safety guidelines.
- Remember not to take over the design process.
- Observe teams to assess and provide feedback on their collaboration, creativity, critical thinking, communication skills, and application of content knowledge.
- Encourage students to plan their presentations and how they will showcase their prototypes using the following sentence stems.
  - We will showcase our bridge and design plan by . . .
  - The steps we followed were . . .
  - The materials we used were . . .
  - First we tried _____, then we _____ . . .

EVALUATE

- Facilitate the presentation and testing process.
- Test each prototype using the same process each time.
- Accept and expect failure; failure is an opportunity to learn and improve.
- Ask questions to help students think critically about the successes and failures of their designs.
- Assign each team or student one of the sentence stems below to guide reflections on the testing of the bridge. You may choose to have students record their reflections in their notebooks or to share them orally with the class.
- Allow time for students to ask questions of each other, reflect, and note their observations. Facilitate the use of the rubric.
- Students will be proud of their work. take pictures as each bridge is tested so that students can have a record of their team's bridge. Display the bridges at school and then draw names to determine which team member will get to take home their team's bridge. Alternatively, carefully disassemble each bridge and reuse the materials.

TEST PROCESS:

1. Create a class chart to record each team's budget and the amount of mass each bridge holds.

Team	Budget ($)	Load (g)

2. Instruct the Project/Quality Control Manager to place their team's bridge across the river.
3. Instruct the Project/Quality Control Manager to place the truck loaded with pre-measured objects on the bridge. *Note: If the truck will not fit or balance on a bridge, the team may have the opportunity to redesign and test their bridge, as time allows.*
4. Instruct the Construction Manager to record and calculate the amount of mass added to the truck as the Project/Quality Control Manager adds mass until the bridge collapses or all of the pre-measured objects and 300 grams of known masses have been added.
5. Keep track of the amount of mass each bridge holds and compare as a group to determine the best bridge design.
   - o Did the bridge fall or collapse?
   - o Did the truck stay on the bridge?
   - o How much mass did the bridge hold?

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TEACHER GUIDE | ENGINEERING DESIGN PROCESS (EDP)

EVALUATE
continued

FACILITATION QUESTIONS:

- Was your bridge effective?
- What materials did your team use? Are there different materials available that might work better?
- What worked? What did not work? What could work better?
- What can you learn by looking at other teams' bridges?
- How does your design meet the constraints and criteria?
- What happened when you tested?
- What could your team do better?
- What can be done to make your bridge even better?

SENTENCE STEMS:

- I observed . . .
- The part(s) that work(s) is/are . . .
- The part(s) that did not work is/are . . .
- The part(s) that could work better is/are . . .
- We know we were successful because . . .
- We know our design met the criteria because . . .
- When we tested, we learned . . .
- When we observed other presentations, we learned . . .
- To make our bridge better, we could . . .