

Design a Bridge

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for the STEM Education Center at WPI's STEM Educator Certificate Course

Subject: Tech/Eng, Math **Grade Level:** 7 **Standards:** MA STE, Math & ELA (Common Core)

Overview

You are designing a bridge as an overpass over highway 146 (near Tony's Pizza) and must submit a bid to the town for the project. Create a model and explain to the select board your design idea, the components of the bridge you chose; the cost of the materials, as well as how it will handle the live load and other forces that will act upon it.

Students will learn about four common bridge designs as a jigsaw (students will research one type of bridge design and share their findings with others). Each group will choose a type of bridge to design and each student will make a scale drawing of their model. The group will use a given scale factor to calculate the length and height of the bridge, and road surface area of the actual bridge, and then build it with given materials. They will test the strength of the bridge, measure its mass and calculate its efficiency (strength: weight ratio), and redesign (following the EDP), and give a final presentation to the town select board members.



Standards

Note: Detailed learning targets and suggested vocabulary can be found [here](#)

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.

7.G.A.1: Solve problems involving scale drawings of geometric figures, such as computing actual lengths and areas from a scale drawing, and reproduce a scale drawing on a different scale

ELA Grade 7 Speaking & Listening Standards. Presenting knowledge and ideas:

4. Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate vocabulary, eye contact, volume and pronunciation.

5. Include visual displays in presentations to clarify claims and findings and emphasize salient points

STE Practice: Construct Explanations and Design Solutions

Assessment

[Performance Assessment Rubric](#)

Prior Knowledge

- Engineering design process
- How to use the miter box and saw to cut the cardboard beams to the correct length and angle
- Scale drawings: scale factor
- How to measure length with a ruler & how to measure mass with electronic balance
- Orthographic drawings (side view and top view)
- Efficiency calculations (strength to weight ratio)

Materials

- Cori Create cardboard beams
- Miter boxes
- Craft saws
- Hot glue guns
- Glue gun sticks
- String

Resources

- [Nepris \(ASA Engage\) Mohamed Ahmed, EIT, Bridge Designer from Clark Dietz, Inc.](#)
- [PBS Learning Media: Structural Engineering of Nests](#)
- [Khan Academy: Smart buildings, transports, and grids](#)
- [Bridge Design and Destruction \(part 1\)](#) (Khan Academy)
- [Bridge Design and Destruction \(part 2\)](#) (Khan Academy)
- https://www.teachengineering.org/activities/view/ucd_bridge_activity1

Timeline of Activities

Each lesson takes one, 50 minute class period.

[Student Instructions](#)

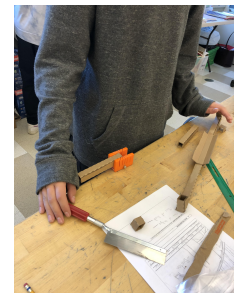
Duration	Activity	Instructions	Product
1 class (50 minutes)	Introduce problem; discuss bridge designs	Show videos from Khan Academy as intro to different bridge designs. Student groups formed and will research different bridge designs in a jigsaw. Report findings to the group.	Choice of which type of bridge to design and build
1 class	Review scale drawings; groups sketch bridges (top view and side view) as an orthographic projection	Review orthographic projections Assign roles: sketch of top view, side view, calculate bridge length, and road surface area of model (actual). Students will make sketches which must be approved by the teacher before they can begin to build.	Sketches of bridge (top & side views); Calculations of length and area
1 class	Use cori beams and hot glue to build bridges; Test strength of bridge with bucket and bricks/rocks	Students will follow their plans (sketches) to build their bridges. The strength of the bridges will be tested by placing between two chairs and hanging a bucket on the bridge. Bricks/rocks will be added to the bucket to determine the maximum load it can sustain.	Bridges Strength of bridge determined
1 class	Students will redesign bridges & complete testing of bridges and prepare presentations	Finish testing the strength of the bridge Calculate the strength efficiency (strength to weight ratio) Redesign and test again. Calculate strength efficiency of redesign Prepare presentation for town officials	
1 class	Presentations	Students will explain their bridge design and show model to town officials	Presentations

Culturally Responsive Teaching Strategies

Culturally diverse experts	Students will watch several videos in their research, some of which are experts talking about their work, and are from culturally diverse backgrounds.
Place-Based Education	Making a positive impact on our community All of our students are impacted by the traffic situation at this intersection. Whether they are riding in the car with their families or on the school bus, they know there is a wait at this light to cross 146. This real world problem affects all residents of our town and all students can identify with the situation. This project empowers them to make a positive change in their community.
Student Agency	Students are taking on the role of a structural engineer, and are choosing the type of bridge to design and build. They may also decide to design the bridge to go over highway 146, or go over Boston Road. By giving students choice in their hands-on project, learning by doing, testing their ideas to see what works and more likely to be engaged. If they are not successful they can redesign and improve their model bridge. Through this process they are taking ownership of solving the traffic problem in their community.

Technology

- Rulers to measure their lines in their sketches, cori beams, length and height of bridges
- Miter box to cut the cori beams (can make precise angles with the miter box)
- Craft saw to cut the cardboard cori beams
- Electronic balance to measure the mass of their bridge and weights it could hold
- Google earth to measure the dimensions of the intersection
- electric balance
- Miter box (orange), craft saw



Group Work

Students will read the list of [roles/skills needed](#) for this project, then highlight in yellow the roles/skills they can complete with little or no assistance, and blue the ones they can complete with moderate assistance. Then I will give them a few minutes to form their group of four, making sure they have all of the roles/skills assigned with students who can complete them.

Students will reflect on their role in their group, how the group worked together, workplace skills they used, as well as feedback to me so I can make improvements to the project, by completing this [Reflections and Survey form](#).

Career Connections

Nepris (now [Pathful Connect](#)) is a wonderful online platform that connects classroom teachers and students with industry professionals. I will request a structural engineer to speak with our students (zoom) about their career, and/or invite them to mentor the students during the project. Students will complete an [activity sheet](#) which will encourage them to ask questions and think about the career of a structural engineer.

Extensions or Modifications

Students with special needs can participate in this project with accommodations. Accommodations include a [calculation sheet](#) with examples of how to calculate the length and area, with problems color-coded so students can use their own measurements to calculate the length and area of their own bridge.