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| **Bridges and Structures - Grade Five** |
| **Lesson Objective:** The Popsicle Bridge lesson has both academic and teamwork objectives. Academic Objective: Students will design and construct popsicle stick bridges using specified materials. Their design process will be informed by observations they make of existing bridges and information provided by their teacher prior to construction. Teamwork Objective: Students will work in teams to build their bridges. Skills involved in the construction process include: presentation of one’s ideas, compromise and negotiation, collaboration on a final product, and supportive language.  |
| Materials:* Reference Books:
	+ Hurley, Michael. The World’s Most Amazing Bridges. Raintree; Chicago, Illinois. 2012
	+ Johmann, Carol A. and Elizabeth J. Reith. Bridges! Amazing Structures to Design, Build, and Test. Williamson Books; Nashville, Tennessee. 1999.
* Tacky glue - 1 8 fl. oz. bottle per group
* Popsicle sticks - 4 ½ x ⅜ x 1/12 in. - 200 sticks per group
* Rulers
* Meter sticks (for measuring span)
* Barbell weights in 5 lb. increments
* Supplementary Web Sources:
	+ <http://travel.cnn.com/explorations/none/24-worlds-most-amazing-bridges-062644> (Bridge images)
	+ <https://www.youtube.com/watch?v=j-zczJXSxnw> (Tacoma Narrows Bridge Collapse)
* Lesson Handouts (Attached to the end of this document, and as a PDF file in the Google Drive Folder)
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| CONTENTSTANDARDS | Core Content:**Engineering Design:**1. Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)
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-ETS1-2)
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. (3-5 ETS1-3)
4. Defining and Delimiting Engineering Problems
* Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the design features of a solution (criteria). (3-5-ETS1-1)

 5. Developing Possible Solutions* At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs, (3-5-ETS1-2)
* Tests are often designed to identify failure points or difficulties, which suggest, the elements of the design that need to be improved. (3-5-ETS1-3)

**Science and Engineering Practices:**1. Developing and Using Models:
* Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.
* Use models to describe phenomena. (5-PS3-1)

 2. Engaging in Argument from Evidence* Support an argument with evidence, data, or a model. (5-LS1-1)

3. Obtaining, Evaluating, and Communicating Information* Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (5-ESS3-1)

 4. Planning and Carrying Out Investigations * Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. (3-5-ETS1-2)

**Analyzing and Interpreting Data*** Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.
* Analyze and interpret data to make sense of phenomena using logical reasoning. (5-ESS1-2)

  **California English Language Development Standards:**[http://www.cde.ca.gov/sp/el/er/documents/sbeeldstdg5c.pdf](http://www.cde.ca.gov/sp/el/er/documents/sbeeldstdg4c.pdf)Students at all ELD levels will work on: Listening actively, (Interacting in Meaningful Ways-B. Interpretive) and Presenting the class with a small group (Interacting in Meaningful ways-C. Productive). Students will also work on being able to support their opinions and using academic vocabulary relevant to the lesson (Selecting language resources). |
| Assessment:Sets of five pound weights will be placed on each bridge until it collapses, or slips from its anchor points.  |

Suggested Lesson:

* Introduce the lesson by explaining the lesson objective to the kids. Be sure to thoroughly explain the materials students will have available to them, the physical setting in which their bridge will be tested, and the weight requirements.
* Ask students what they know about bridges. (What is the purpose of a bridge? What materials are they made of? What bridges do they frequently use themselves?)
* Show students several photos of real bridges. (The CNN site listed as a supplementary source provides a nice variety.)
	+ Ask kids to point out features that the bridges have in common.
* Next, pass out the “Types of Bridges” page from Tryengineering.org.
	+ Explain that we will be constructing bridges out of popsicle sticks and glue. Have the students talk in table groups or partners to decide which types of bridges will be feasible given those materials.
* Once students have determined which styles of bridge they are capable of building, pass out the “Design Your Own Bridge Worksheet”.
	+ Have students spend 5-10 minutes sketching a bridge design of their own.
	+ Assign students to groups.
	+ Ask groups to share their individual bridges, looking for common features and design ideas.
	+ Tell the groups to come up with a group plan for their bridge, reminding them they will only have 200 popsicle sticks and glue, their bridge must hold at least five pounds of weight, and must stretch across a span of 14 inches.
* Once students have a plan sketched out, provide them with their materials. (Suggestion: Cafeteria trays work well for supply dissemination and make it easy to store bridges while they’re under construction.)
* Construction time will vary, however, at least two hours should be set aside for this task.
* When the bridges are completed, schedule a bridge testing day.
* Bring in barbell weights in 5 pound units.
* Set up the test site with a span of 14 inches.
* Test the bridges one at a time to see how much weight they can hold. (Filming the actual breaking point in slo-motion is recommended as students can see where their bridges weak spots were.)
	+ Before each bridge is tested, ask the construction team to show it to the class and explain its features. Have the students use the provided rating sheet to judge the bridge for aesthetic value.
* Ask students to complete the reflection portion of the “Design Your Own Bridge Worksheet”.
	+ After everyone has completed the worksheet, have a class discussion about what students learned from the construction and testing process.
		- What features of the bridges seemed most important to a successful outcome?
		- What would they change in their designs, if given the choice to rebuilt?
		- What teamwork lessons did they learn from this process?
		- How could their team have worked more effectively?
* Ask students to think about their own design and process. Explain the importance of failure in scientific experiments and challenge them to design a second bridge that addresses their primary failure points. (Actual rebuilding is up to the teacher.)

Optional Extension:

To extend the project, rather than providing the students with the materials, offer a larger variety of choices in building materials, but assign a cost to each item. Students could be given a price limitation and asked to design a bridge that will come in at or under cost.

The following pages contain student materials

 referenced in the lesson above.

Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

#:\_\_\_\_\_\_\_\_

Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Popsicle Bridges Aesthetics and Predictions Form

Directions: You are to give each group a grade of a 1-5 for aesthetics-how the bridge looks. A score of a “1” means that it looks like the group didn’t place much importance on aesthetics (not appealing); while a “5” means that it looked professional and very appealing. Please circle ONE number.

Next, you are to make a prediction of how much weight you think the bridge will hold. Once the weight has collapsed the bridge, write down the final amount that it took to do so. Then, find the difference between your prediction and the actual weight the bridge held.

**1. Group #1**

Aesthetics: 1 2 3 4 5

Weight prediction: \_\_\_\_\_\_\_\_\_\_\_

Actual weight: \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Difference between the two: \_\_\_\_\_\_\_\_\_\_\_\_\_\_

**2. Group #2**

Aesthetics: 1 2 3 4 5

Weight prediction: \_\_\_\_\_\_\_\_\_\_\_

Actual weight: \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Difference between the two: \_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Peer Rating of Individual’s Participation in Popsicle Stick Bridge Models**

**Teammate’s Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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| --- | --- | --- | --- |
| **4 – Outstanding** | **3 – Good** | **2 – Could be better** | **1 – Needs teacher guidance** |

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| --- | --- |
| *Listened attentively to others* |   |
| *Shared thoughts and ideas* |   |
| *Asked questions* |   |
| *Worked as part of the team* |   |
| *Polite and respectful* |   |

**Suggestions for future group work:**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

#:\_\_\_\_\_\_

Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Bridge Reflection

1. Did you decide to revise your original design while in the construction phase? Why?

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2. What design elements of other bridges did you like the best?

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3. If you had to do it all over again, how would your planned design change? Why?

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4. What sort of trade-offs do you think engineers make between functionality, safety, and aesthetics when building a real bridge?

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