POPSICLE STICK BRIDGE CONTEST

Introduction

As you may be aware, the year's TechnoChallenge includes a popsicle stick bridge building contest. This is a fun and easy event to run in your classroom, and it connects to well to the science curriculum.

What follows is an outline as to how you can run such a "contest" in your classroom and meet the expectations of the curriculum at the same time. This is not, however, a set of prescriptive lesson plans. It is, however, a collection of ideas and helpful hints from someone who has had a great deal of fun running this classroom contest over the past ten years.

The Contest

The challenge can be stated quite simply.

- Students must construct a bridge made of popsicle sticks and carpenters glue. No other materials may be used. Standard popsicle sticks are 11.5 cm long, 1 cm wide, and approximately 0.2 cm thick.

- The bridge must span a gap of 60 cm.

- The bridge must not weigh more than 500 grams.

- The bridge must have a smooth continuous driving deck that spans the entire length of the bridge. This deck must be unobstructed and 8 cm wide.

- The load will be applied to the deck of the bridge by means of a rope or strap that will hold the weight below the bridge. An opening of 40 mm by 10 mm should be left at or near the middle of the deck to allow the strap.

- Students must incorporate structural elements learned in class (e.g., laminated beams, trusses, sway bracing, etc.)

I always make it a goal for the students to make a bridge that will support at least 100 pounds. Each year, more than half of the class is able to achieve this goal.

Evaluation

In the appendix, I have provided a sample rubric that could be used when marking this assignment.

When evaluating the bridge, you may wish to look at the following:

- The amount of weight held.
- The ratio of the weight held to the bridge weight.
- The incorporation of structural elements learned in class.
- The use of materials and the aesthetic appeal of the bridge.
- Student responses to questions like the following (see notes in the Appendix):

  Identify and discuss the design elements that you incorporated into your bridge.

  Identify and describe at least three of the common design elements among the bridges that successfully supported 100 lbs.

  Identify and explain at least three improvements that you could make to your bridge, or things that you could do differently, so that your bridge would meet the design criteria more effectively.

Curriculum Expectation

The following grade 7 curriculum expectations are integrated into this project:

3.2 describe ways in which the centre of gravity of a structure ***(e.g., a child's high chair, a tower)*** affects the structure's stability	**3.4** distinguish between external forces ***(e.g., wind, gravity, earthquakes)*** and internal forces (tension, compression, shear, and torsion) acting on a structure
3.5 describe the role of symmetry in structures ***(e.g., aesthetic appeal, structural stability)***	**3.6** identify and describe factors that can cause a structure to fail ***(e.g., bad design, faulty construction, foundation failure, extraordinary loads)***
2.1 follow established safety procedures for using tools and handling materials ***(e.g., wear safety glasses when cutting or drilling)***	**2.2** design, construct, and use physical models to investigate the effects of various forces on structures
2.3 investigate the factors that determine the ability of a structure to support a load	**2.4** use technological problem-solving skills (see page 16) to determine the most efficient way for a structure ***(e.g., a chair, a shelf, a bridge)*** to support a given load
2.6 use appropriate science and technology vocabulary, including ***truss, beam, ergonomics, shear,*** and ***torsion)***, in oral and written communication	**2.7** use a variety of forms ***(e.g., oral, written, graphic, multimedia)*** to communicate with different audiences and for a variety of purpose

Lessons

In order for students to be successful with this project, you should provide lessons about the following topics. Most grade seven science texts cover most or all of these topics.

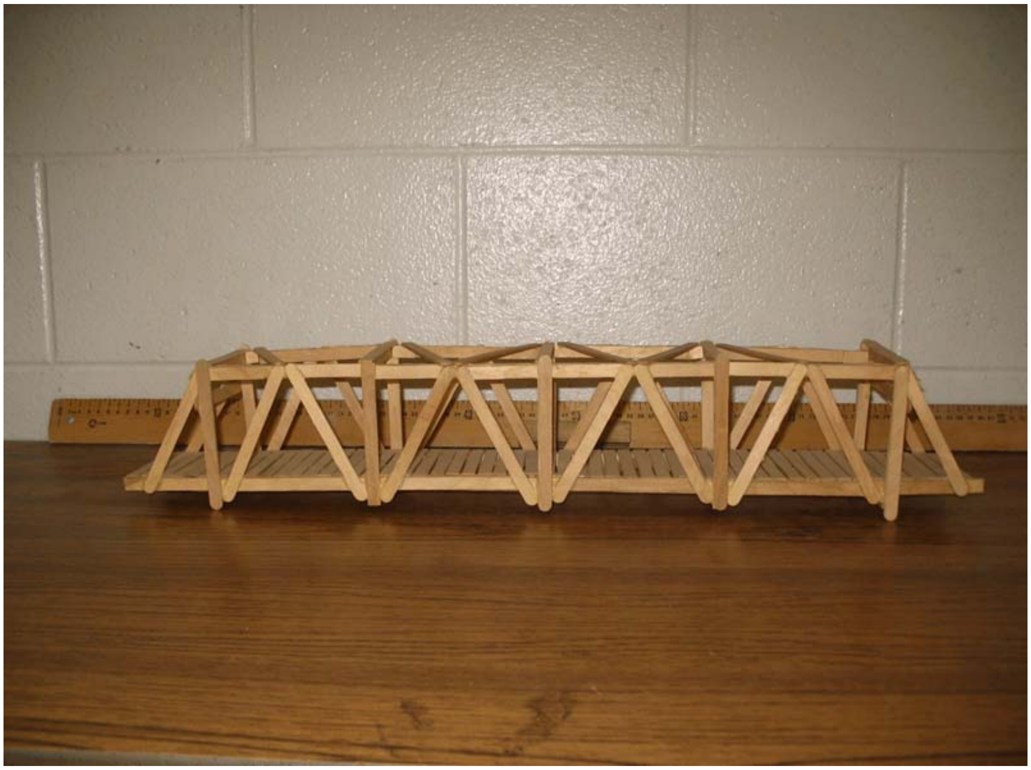
- centre of gravity and its effects on structures (e.g., keep centre of gravity low and positioned over the centre of the base)
- symmetry and its role in structural strength and stability, and aesthetic appeal
- internal forces such as tension, compression, torsion, and shear (use demonstrations or student investigations here)
- static and dynamic loads
- the strength of triangles (do an investigation as to why they are so strong)
- types of trusses (e.g., Pratt, Warren, Howe, K-Truss, etc.) and the use of gussets
- ties and struts and how they resist tensile and compressive forces
- types of bridges (beam, arch, suspension, etc.) and when each is used
- types of beams and their uses (e.g., laminated beams and I-beams)
- the importance of bracing and sway bracing
- how to create laminated beams using popsicle sticks (and the importance of turning them on their sides)
- how to create and incorporate triangles into a structure using popsicle sticks
- how and why to use cross bracing and sway bracing in popsicle stick structures

What do finished bridges look like?

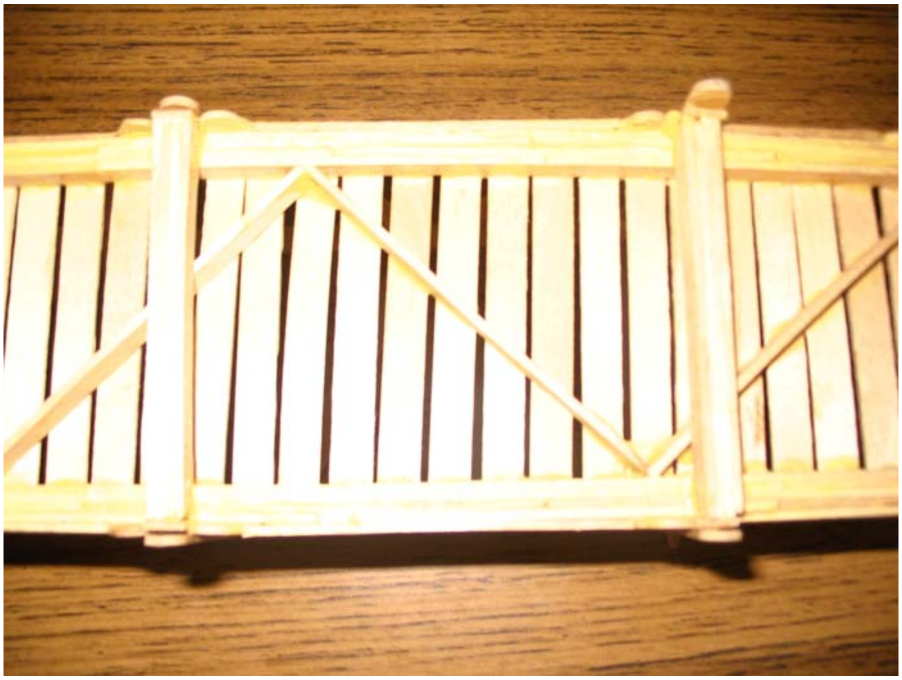
Below are actual bridges that students created for this project. Please note that these are some of the best designs from the past ten years. By no means do all students create bridges like these.

This was one of the strongest designs for its weight. The bridge could have been improved if the arch spanned the entire bridge length. Note the simple “X” cross-bracing at the top.

This is a very common design among students. Note the use of triangles along the sides, and the cross-bracing and sway-bracing across the top and at the ends.



The photo below shows bracing across the bottom of a bridge. Note that the deck should be continuous.



This is another

excellent design. This students had help from his father with using a power sander to “round” the top corners (in his initial design, the popsicle sticks stuck up and out slightly at the corners). I have no problem with parental support in a situation like this. The student knew what he wanted to do, he just need adult support to do it.

The students who built the next bridge first designed it using the West Point Bridge Builder software (a free download) that they downloaded from the internet. They then printed out a schematic and built it from there. The bridge was much too heavy, but it didn’t even creak under the weight of 150 lbs.!

It is up to you as to whether or not you allow this bridge to be constructed at home. If it is constructed at home, the student's ability to answer questions about the bridge (e.g., its design and construction) become much more important than the bridge itself. Simply adjust your own rubric to meet the guidelines you set out at the start of the project.

Testing the Bridges

I've found that the easiest way to test the bridges is to suspend a dumbbell bar below the bridge using a rope. The photos below show how this is done.

I usually start with 50 lbs. on the bar, and go up in 5 lb. intervals using 2.5 lb. weights added to each side of the bar. If a bridge breaks at 65 lbs., then I count the weight held as 60 lbs. (that is, I count the last interval of 5 lbs. that it successfully held). Use iron plates instead of plastic plates filled with sand. The iron plates are narrow, and you can fit on more weight.

In order to protect the floor, place some old textbooks directly below the weights. This way, if the bridge fails, you won't break your tile floors (and it gives you the opportunity to finally put those Interactions texts to good use!).

Also, have all students wear safety goggles. If a bridge fails, pieces of wood can fly off.

Helpful Hints

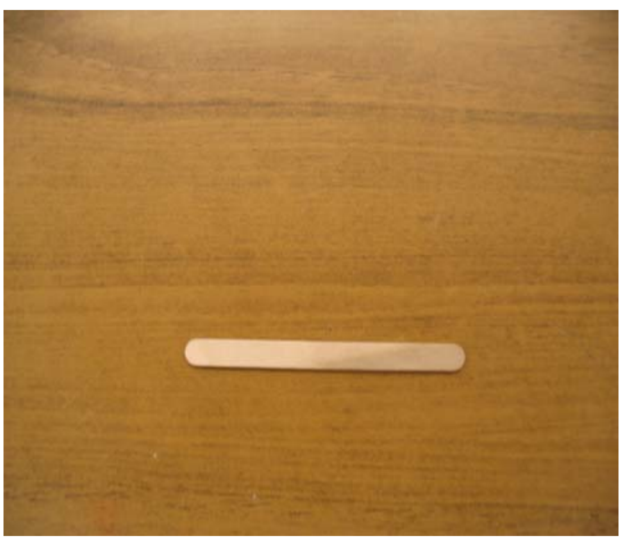
- Students should use only popsicle sticks and carpenter's glue. The glue from a glue gun is weak and flexible.

- Students should be shown how to create a laminated beam, trusses, and sway braces.

  Here are some hints for laminated beams.

  1. Place a popsicle stick on the table.
  2. Glue a second to the right of centre on the first.
  3. Glue a third to the left of centre on the first.
  4. Glue a fourth opposite the first, on top of the second and third.
  5. You now have a base to create a laminated beam three popsicle sticks wide. Turn the beam on its edge during the construction of the bridge.

1.



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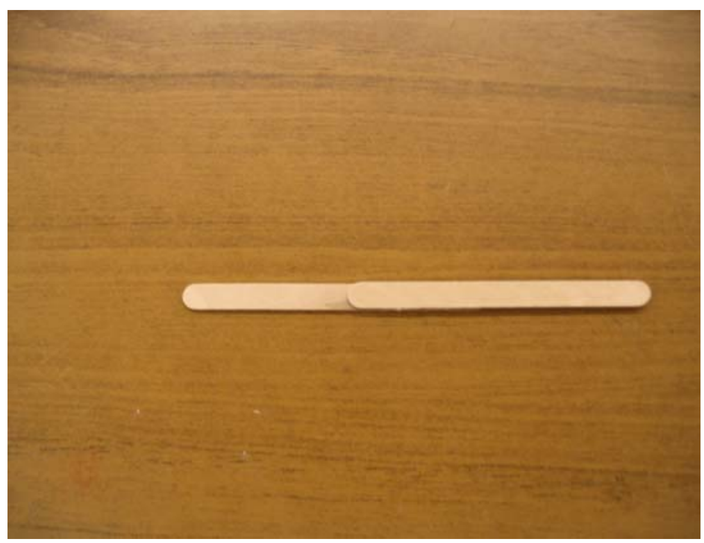

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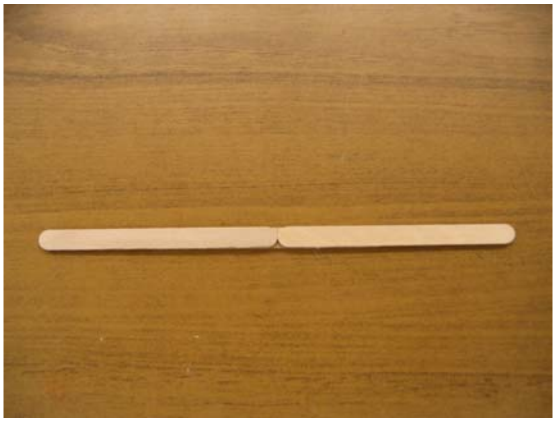

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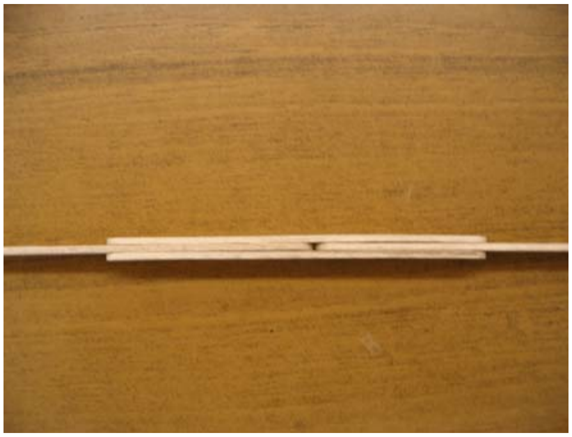


Let the students figure out how to incorporate triangles, trusses, cross-bracing and sway-bracing.

- Always keep successful bridges from years past. These will act as models for the students.

- Establish a “100 Pound Club” in your class. Bridges that successfully hold 100 pounds will be admitted into the club, and the bridges will displayed in the school. It’s amazing how much your students will want to join this prestigious club.

- Don’t underestimate your students. They may get off to a slow start, but they’ll come through in the end.

<u>Should the bridges be built at home or at school?</u>

This one is up to you, and will depend on what you want to evaluate.

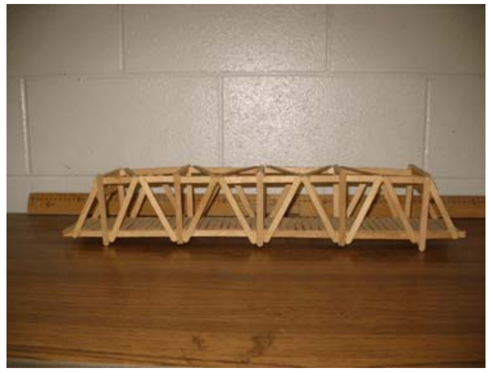
By letting kids take the project home, you're giving parents the opportunity to be involved with the project and learn alongside their child. This is a valuable learning experience for both the parent and the student. On the other hand, you also give parents the opportunity to do the project for the student.

By having the project completed at school, you'll need to set aside many hours, over a period of two or more weeks, to get the bridges constructed. You'll be sure that there's no parental support for the project, but the project is time consuming.

Whatever you decide, ensure that your rubric reflects what it is you want to evaluate.

APPENDIX

Popsicle Stick Bridge Contest



The Challenge

Your challenge is to build a bridge that meets the following criteria.

- You must construct a bridge made of popsicle sticks and carpenters glue. No other materials may be used. Standard popsicle sticks are 11.5 cm long, 1 cm wide, and approximately 0.2 cm thick.
- The bridge must span a gap of 60 cm (so make it about 70 cm long so that there's support at either end).
- The bridge must not weigh more than 500 grams.
- The bridge must have a smooth continuous driving deck that spans the entire length of the bridge. This deck must be unobstructed and 8cm wide.
- The load will be applied to the deck of the bridge by means of a rope or strap that will hold the weight below the bridge. An opening of 40 mm by 10 mm should be left at or near the middle of the deck to allow the strap (see below).

- You must incorporate structural elements learned in class (e.g., laminated beams, trusses, sway-bracing, etc.)
- You will be asked to discuss the design elements used in your bridge at the end of the project.

Bridge Questions

1. Identify and discuss the design elements that you incorporated into your bridge. Your explanations as to why you chose each element should be quite detailed. Set them up as shown below.

   Design Element: (provide a description of the design element)

   Why I chose to use this design element: (provide an explanation as to how and why you thought this design element would improve your structure)

2. Identify and describe at least three of the common design elements among the bridges that successfully supported 100 lbs.? Why were these design elements so effective? Set up each of your three answers as shown below.

   Design Element: (provide a description of the design element)

   Why this design element was so effective: (provide an explanation as to why this design element was so effective)

3. Identify and explain at least three improvements that you could make to your bridge, or things that you could do differently, so that it would meet the design criteria more effectively. This could include a discussion of design elements, use of materials, time management, parental or partner support, etc.

Bridge Design Rubric

Criteria	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Weight Held	50 - 60 lbs.	61 - 70 lbs.	71 - 80 lbs.	81 - 100 lbs.
Ratio of weight held to bridge weight	less than 80:1	80:1 to 90:1	90:1 to 112:1	greater than 113:1
Design Elements -incorporates the design elements (beams, trusses, triangles, braces) learned in class	-incorporates few to no design elements learned in class -design elements are ineffective	-incorporates a few of the design elements learned in class -design elements are not always used effectively	-incorporates a number of design elements learned in class -some design elements are used effectively	-incorporates many design elements learned in class, or elsewhere -design elements are used in an effective and efficient manner
Use of Materials and Aesthetic Appeal -the bridge is symmetrical -the materials have been used neatly and effectively	-bridge lacks symmetry -most of the materials are put together ineffectively and are sloppy	-bridge is almost symmetrical -some of the materials a put together ineffectively and are sloppy	-bridge is symmetrical -most of the materials are put together neatly and effectively	-bridge is symmetrical -materials are put together in a neat and highly efficient manner
Discussion of Design Elements -students is able to discuss how and why they used certain design elements	-the student demonstrates little understanding of the design elements used in their bridge	-the student demonstrates some understanding of the design elements used in their bridge	-the student demonstrates a considerable understanding of the design elements used in their bridge	-the students demonstrates a thorough understanding of the design elements used in their bridge
Discussion of Design Elements -student is able to discuss the design elements common to bridges holding 100 lbs.	-the student demonstrates little understanding of the design elements common to bridges holding 100 lbs.	-the student demonstrates some understanding of the design elements common to bridges holding 100 lbs.	-the student demonstrates considerable understanding of the design elements common to bridges holding 100 lbs.	-the student demonstrates a thorough understanding of the design elements common to bridges holding 100 lbs.
Reflection -students provides a thorough reflection about the project	-student provides little reflection about design elements, use of materials, or ways to improve the project	-student provides some reflection about design elements, use of materials, or ways to improve the project	-student provides a thoughtful reflection about design elements, use of materials, or ways to improve the project	-students provides and thoughtful and thorough reflection about the design elements, use of materials, or ways to improve the project