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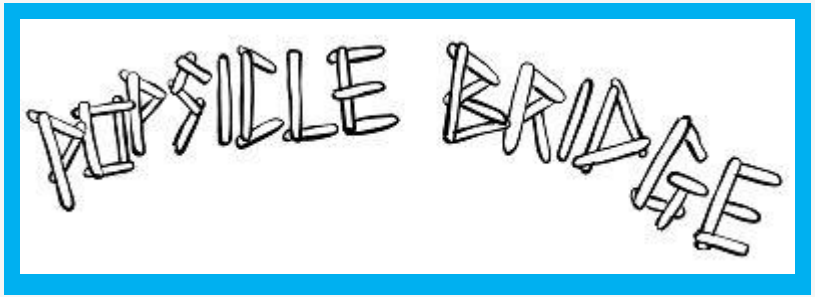
TRY Engineering

Lesson Plan:

Popsicle Bridge



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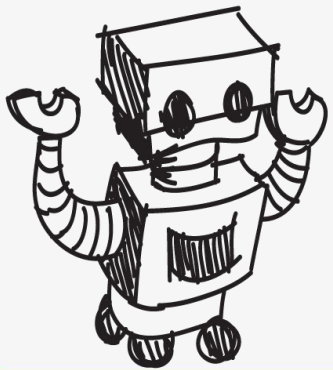
Real-World Application



Langkawi Sky Pedestrian Bridge – Malaysia

Wikipedia

- 125 meters long, and 1.8 meters wide
- Designed as a curved walkway to maximize the viewing experience.
- Formed of steel and concrete panels set on top of an inverted triangular truss.
- Suspended by 8 cables from an 81.5m high single pylon, and hangs at about 100m above ground.
- Designed to carry a maximum capacity of 250 people.

Source: Wikipedia https://en.wikipedia.org/wiki/Langkawi_Sky_Bridge

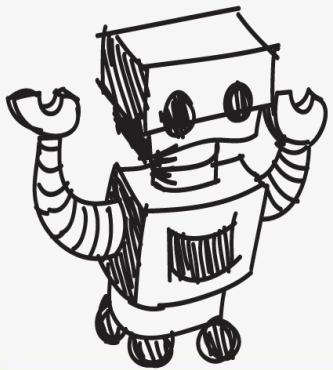
Florida Int'l University Pedestrian Bridge Collapse

- A poor design led to the collapse of a pedestrian bridge under construction at FIU in 2018. Engineers incorrectly calculated the amount of stress the structure could take.

Wilfredo Lee, AP

Source: USA Today
https://www.usatoday.com/story/news/nation/2019/10/22/design-error-blamed-florida-international-university-pedestrian-bridge-collapse/2449316001/

The Design Challenge



The Design Challenge

- You're a team of engineers working to design a bridge using glue and 200 popsicle sticks or less.

Defining the Challenge: Criteria & Constraints

Criteria

- Bridges must be able to hold a pre-determined weight
  - 5 pounds or 20 pounds
- Structure must span a minimum of 14 inches in length.

Constraints

Can use no more than 200 popsicle sticks.

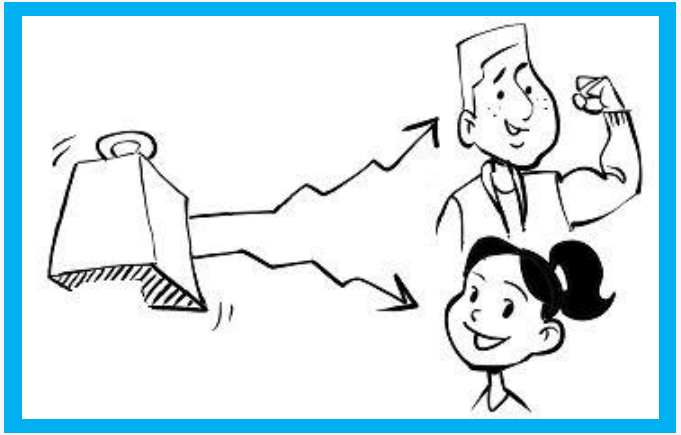
Materials

Build Materials

- 200 popsicle sticks
- Wood or craft glue

Testing Materials

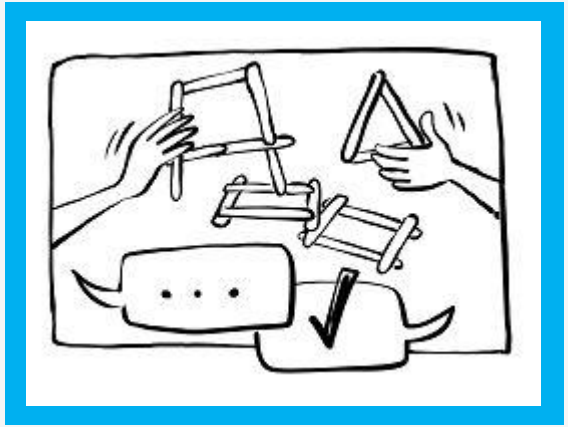
- 5 pound weight (for younger students) and 20 pound weight (for older students)
  - (bags of sugar or flour, 16 oz. cans of food, 72 oz. bottle of laundry detergent, exercise weight, or another weight)
- 2 chairs, desks or small tables (tall enough to allow for designs to be suspended 1 foot above the floor)



Consider...

Before you get started brainstorming...consider the following...

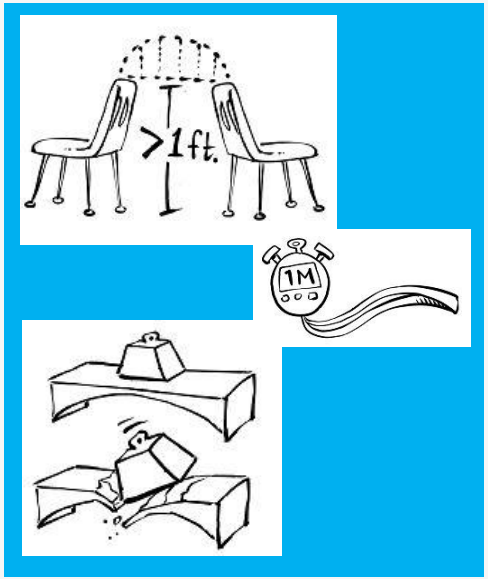
- Different types of bridges
- Which shapes are stronger than others?
- Amount of weight your design must hold
- 14” span criteria
- Aesthetics – be creative
- Efficiency – try not to use all of the popsicle sticks



Testing Process

Testing Process

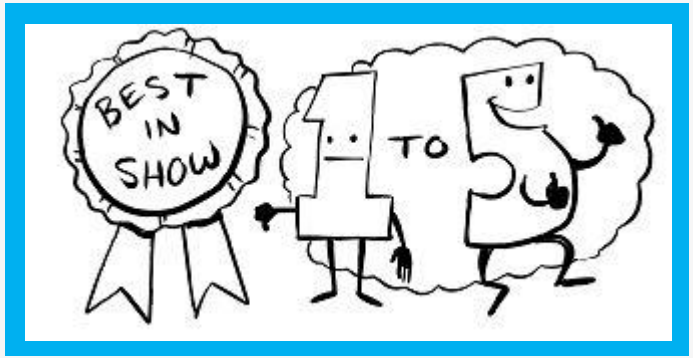
- Place 2 chairs or desks (flat surface) a minimum of 14” apart from each other
- Suspend or tape a bridge 1 foot above the floor on top of the chairs/desks
- Place the predetermined weight on the bridge for one full minute
  - Depending on the type of weight selected, it can be placed on top of the design or hung from below.



- The goal to test the designs to meet the minimum load. However, it’s fun to keep adding weight to the structure to meet the critical load resulting in a crumbling bridge!

Judging the Designs

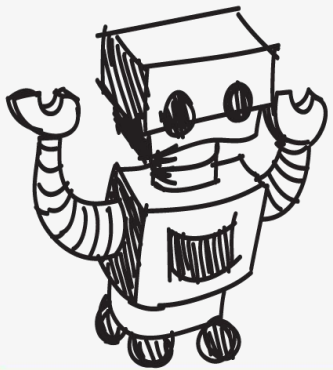
- As a class, discuss what makes a bridge aesthetically pleasing
  - Develop a list of attributes in preparation for the judging
- Next, judge each bridge design for its aesthetic value
  - Use a scale of 1-5, with 1 being “not at all appealing,” and 5 being “very appealing.”
- Give 1 positive comment and 1 suggestion for improvement for each design.



Variation for Older Students

- Design and build a bridge out of popsicle sticks and glue that can hold the weight of:
  - Two students
  - Three students
- Remember to keep safety in mind, if you try this variation

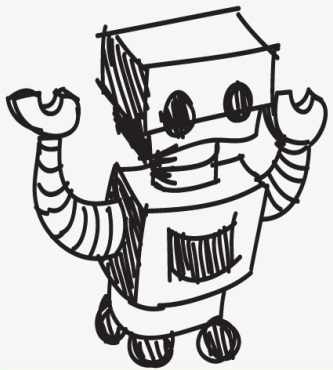
Reflection & Debrief



Reflection

- How many popsicle sticks did you end up using? Did this number differ from your plan?
- Do you think that engineers have to adapt their original plans during the construction of systems or products?
- What sort of trade-offs do you think engineers make between functionality, safety, and aesthetics when building a real bridge?

The Engineering Design Process



The Engineering Design Process

Learn about the engineering design process (EDP). The process engineers use to solve problems.

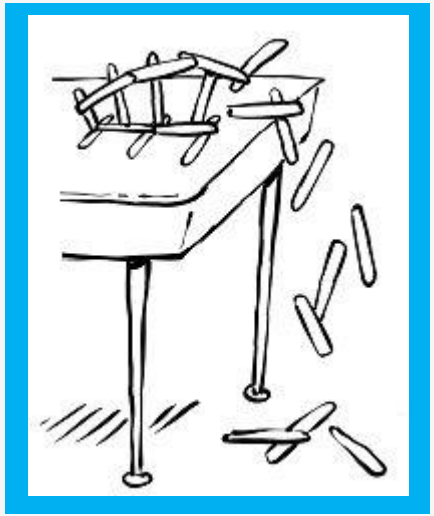
Source: TeachEngineering YouTube Channel

Engineering Design Process

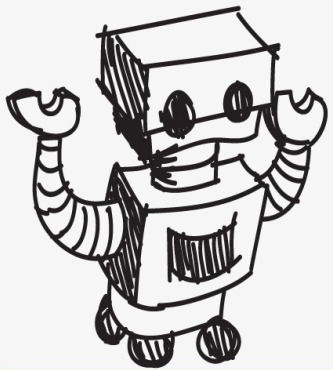
- Divide into teams of two (or up to 4 max)
- Review the challenge and criteria & constraints
- Brainstorm possible solutions (sketch while you brainstorm!)
- Choose best solution and build a prototype
- Test then redesign until solution is optimized
- Reflect as a team and debrief as a class

Productive Failure

- The engineering design process involves productive failure: test, fail, redesign. Repeat (iterate) again and again until you have the best possible solution.
- It is important to document iterations to keep track of each redesign. Use the engineering notebook to sketch ideas, document iterations and any measurement and/or calculations.
- It's also important to showcase the fact that there can be multiple solutions to the same problem. There's no one "right" solution.



Vocabulary



Vocabulary

- Abutment: Part of a structure that receives pressure
- Aesthetic: Appreciation of a beautiful appearance
- Arch: A curved shape. An arch bridge is shaped as an arch and is naturally strong
- Beam: A long piece of heavy often squared wood or steel for use in construction. Beam bridges are horizontal beams supported at each end by piers.
- Cable: A strong wire rope or metal chain. A cable-stayed bridge is held up by cables.
- Cantilever: Horizontal beams that are supported on only one end. Cantilever bridges are built using cantilevers.

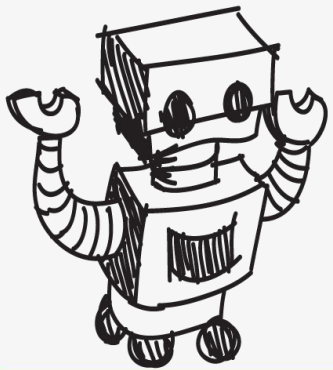
Vocabulary

- Constraints: Limitations with material, time, size of team, etc.
- Criteria: Conditions that the design must satisfy like its overall size, etc.
- Critical Load: Weight at which a building or structure fails
- Engineers: Inventors and problem-solvers of the world. Twenty-five major specialties are recognized in engineering (see infographic).
- Engineering Design Process: Process engineers use to solve problems.
- Engineering Habits of Mind (EHM): Six unique ways that engineers think.
- Iteration: Test & redesign is one iteration. Repeat (multiple iterations).
- Load: A weight or source of pressure put on an object

Vocabulary

- Prototype: A working model of the solution to be tested.
- Span: The spread or extent between supports
- Suspension: Hung in mid air. Suspension bridges are suspended from cables and tend to be long.
- Stress: Pressure or tension exerted on a material object
- Truss: Group of beams forming a triangle shape rigid framework. Truss bridges have a solid deck and a lattice of pin-jointed girders for the sides.

Dig Deeper



Dig Deeper into the Topic

Internet Connections

- Sydney Harbor Bridge History
  - https://www.sydneyharbourbridge.com.au/
- Building Big - Bridges
  - http://www.pbs.org/wgbh/buildingbig/bridge/

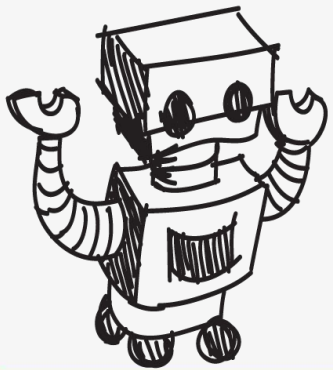
Supplemental Reading

- Bridges of the World: Their Design and Construction (ISBN: 0486429954)
- Bridges: Amazing Structures to Design, Build & Test (ISBN: 1885593309)

Writing Activity

- Write an essay or a paragraph about how new engineered materials have impacted the design of bridges over the past century.

Engineering Fields



What is Engineering?

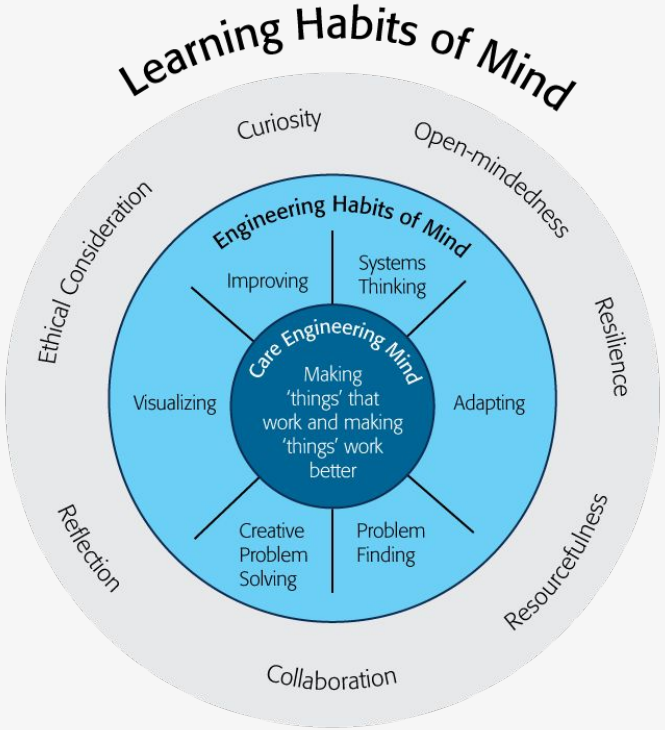
Source: TeachEngineering YouTube Channel

Learn about engineering and how engineers are creative problem solvers and innovators who work to make the world a better place.

Related Engineering Fields

- There are many different types of engineering fields that are involved with designing and building bridges. Here are just some of the related engineering fields.
  - Civil Engineering
  - Environmental Engineering
  - Materials Engineering
  - Mechanical Engineering
- Download the Engineering Fields Infographic
  How will **YOU** change the world?

Engineering Habits of Mind



Engineering Habits of Mind (EHM) is about how engineers think everyday. The Core Engineering Mind is about making things that work and making them work better.

*Source:*https://online-journals.org/index.php/i-jep/article/view/5366)

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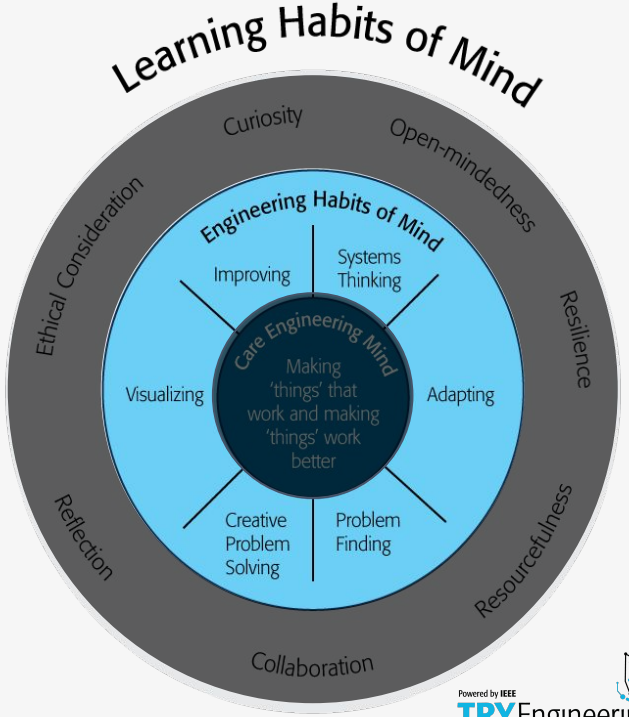
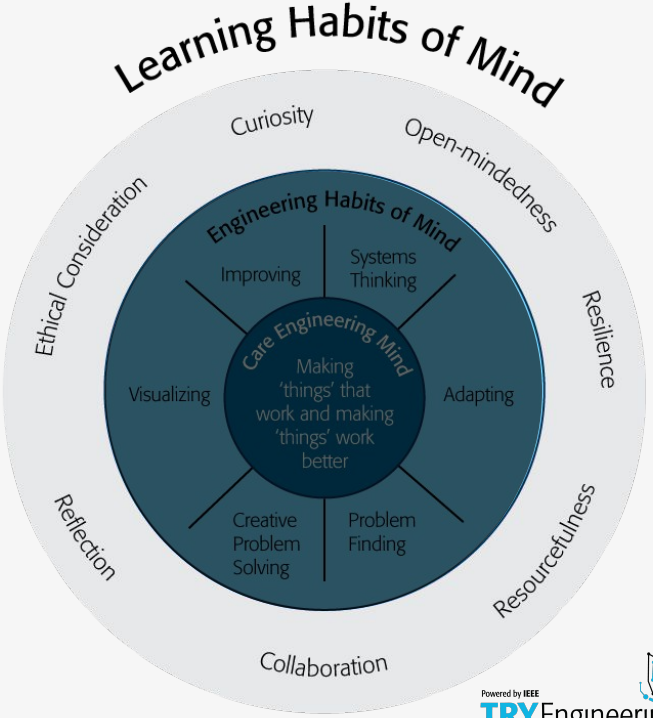
Engineering Habits of Mind Checklist

- Systems thinking
- Problem-finding
- Visualising
- Improving
- Creative problem-solving
- Adapting



Learning Habits of Mind Checklist

- Open-mindedness
- Resilience
- Resourcefulness
- Collaboration
- Reflection
- Ethical Consideration
- Curiosity

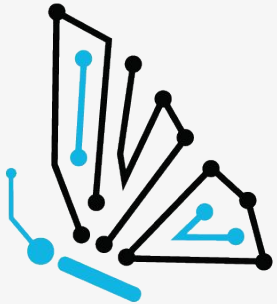


Greatest Engineering Achievements of the 20th Century

Source: http://www.greatachievements.org/

Learn more about how engineers make the world a better place

For more engineering lesson plans and resources like games, engineering careers, and STEM opportunities visit IEEE's TryEngineering.org



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