Lesson/Unit Title: Collaborative Construction: Building Bridges

Grade Level: Middle School (6-7-8)

Lesson/Unit Overview:
Explore the 4 C's (Critical Thinking, Communication, Collaboration, and Creativity) by collaboratively researching, designing, and constructing 3-D bridges. Engage in problem solving, discuss and explore effective design principles, and connect interdisciplinary content standards.

Duration: Approximately four 50-minute sessions

Enduring Ideas: Design is a part of our everyday environment.

Objectives/Outcomes:
Learners will:

- participate in the design process for building collaborative bridges (see attached sheet).
- explore various types of bridge design, including styles, purposes, locations, and materials.
- create sketches of bridges based on their own concepts and the designs researched.
- collaborate with peers to construct one bridge prototype together. They may select one student's design or they may combine attributes from the various sketches to make one new bridge.
- test forces on the prototype/model.
- make revisions to the model as necessary based on test results.
- create a group process book documenting their work.

Content and Achievement Standards:

<u>National Visual Art Standards</u>

6th: VA:Cr1.1.6a	Combine concepts collaboratively to generate innovative ideas for creating art.
6th: VA:Cr3:1:6a	Design or redesign objects, places, or systems that meet the identified needs of diverse users.
7th: VA:Cr1.2.7a	Develop criteria to guide making a work of art or design to meet an identified goal.
7th: VA:Cr2.3.7a	Apply visual organizational strategies to design and produce a work of art, design, or media that clearly communicates information or ideas.
8th: VA:Cr1.2.8a	Collaboratively shape an artistic investigation of an aspect of present day life using a contemporary practice of art and design.
8th: VA:Cr3.1.8a	Apply relevant criteria to examine, reflect on, and plan revisions for a work of art or design in progress.

<u>Next Generation Science Standards</u>
<u>Engineering Design</u>

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

<u>Forces and Interactions</u>

MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

<u>CCSS- ELA: Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6–12</u>

MS: WHST 7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Career and Technical Education – Engineering and Architecture Pathways

B2.1 Understand the process of producing proportional two- and three-dimensional sketches and designs.
B2.2 Apply sketching techniques to a variety of architectural and engineering models.
B6.1 Understand the steps in the design process.
B6.5 Demonstrate the process of developing multiple details, within design constraints, into a single solution.
B6.6 Construct a prototype from plans and test it.
B6.7 Evaluate and redesign a prototype on the basis of collected test data.

Resources:

Images of bridges:

Monet, Water Lily Pond, 1899
Hokusai, Drum Bridge at Kameido Tenjin Shrine, c.1834
Van Gogh, Bridges Across The Seine At Asnieres, 1887
Stella, The Brooklyn Bridge: Variation on an Old Theme, 1939
Websites of bridges available online:
http://www.nps.gov/prsf/planyourvisit/golden-gate-bridge.htm
http://www.aviewoncities.com/nyc/brooklynbridge.htm
http://www.roadtraffic-technology.com/features/featurethe-worlds-longest-cantilever-road-bridges-4181299/
http://10mosttoday.com/10-most-famous-bridges-in-the-world/

Information about bridge design:

http://www.pbs.org/wgbh/buildingbig/bridge/
http://science.howstuffworks.com/engineering/civil/bridge1.htm
https://bridgecontest.org
http://en.wikipedia.org/wiki/Bridges_in_art
https://www.brainpop.com/technology/scienceandindustry/bridges/preview.weml

Materials:

*art straws (http://www.dickblick.com/products/artstraws/)
*plastic corrugated sheets (http://www.dickblick.com/products/corrugated-plastic-panels/) - cut into various sizes (varying from 1" squares to larger rectangular pieces)
*white painter's tape (optional)
*white pipe cleaners (optional)
*scissors
*pencils/erasers
*sketch paper
*rulers
*a bag of coins or other weighted materials (to test forces on the bridges)

Procedure:

DAY 1

- Begin by having students brainstorm/mind-map everything they know about bridges – designs, functions, locations, materials, etc. They may sketch or write ideas, then have then share in table groups or with partners.
- Share images of bridges (in works of art and in photographs), and have students compare what they wrote/sketches with the images. Similarities? Differences?
- Students will begin using the design process. Share the "design process" handout and go over it together so students have a clear idea about the work they will do for this project. Explain that they will be designing a new bridge for their community. In addition to this constraint, they will determine the other parameters (location, use, materials, etc.) for their design process. They will compile a "process book" in which they will keep all their work for this process (sketches, parameters, data* from testing, peer interview)
- Provide students with websites, books, and/or other resources on bridges. Have them work independently or in small groups to learn about various types of bridges and their purposes/functions. They may use a graphic organizer to record information.

DAY 2

- Students will use the information they found through research to propose several designs for a new bridge. They will need to determine the following parameters: use/purpose, location, length, materials, and design elements (proportion, balance, unity). Students will make 3 sketches of bridge variations.
- Have students get in groups of 4-5 people and share their designs. They will either vote on one design or select components of the various sketches to combine in one new bridge design. If this option is chosen, have the students create a new sketch to use as their prototype plan.
- Students will use the materials provided to construct their bridge model. Demonstrate how the art straws can be connected (pinched at the ends and added to one another, taped, connected via corrugated pieces, or with pipe cleaners), as well as twisted, rolled, folded, etc. They do not need to remain linear.

DAYS 3 and 4

- Students will continue building their prototypes.
- When the first round is complete (or near complete), students will test the weight and strength of their bridge, noting any areas that need reinforcement or redesign. They must also consider the real world applications of their bridge for the specific location and purpose they defined in the beginning. Does this prototype still work for those parameters? They will document their findings (data*).
- After testing the bridges, students will make any necessary adjustments, refining the prototypes and documenting their revisions.
- Students will conduct a peer interview of a team member from another group. The interviews will be added to the group process books.

Assessment:

Reflective Peer Interview:

Students will interview a peer from another team and record their responses to the following questions:

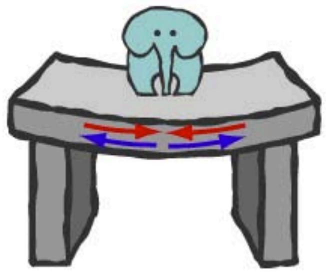
1. Did you discover anything unusual or special while you were working?
2. How did your design change as you were working?
3. Is there still something you would like to change? Why or why not?

Rubric

	5	4	3	2	1
Brain-storming and Planning (Sketches)	Parameters of design problem are clearly identified. More than 3 complete sketches (per student) are presented and align with parameters specified by student.	Parameters of design problem are mostly identified. 3 complete sketches (per student) are presented and align with parameters specified by student.	Parameters of design problem are vaguely identified. 2 complete sketches (per student) are presented and mostly align with parameters specified by student.	Parameters of design problem are not identified. 1 complete sketch is presented.	Parameters of design problem are not identified. Sketches are incomplete or not turned in.
Prototype/ Model And Testing/ Plan for Redesign	Group builds a working model that can be tested for strength using appropriate tools, materials and resources. Group clearly documents what works or doesn't (*data) and proposes many options for improvement.	Group builds a working model that can be tested for strength using appropriate tools, materials and resources. Group documents what works or doesn't (*data) and proposes more than one for improvement.	Group builds a working model that can be tested for strength using appropriate tools, materials and resources. Group provides little documentation of what works or doesn't (*data) and proposes an option for improvement.	Group builds a model but it can't be tested for strength. Group provides no documentation of what works or doesn't (*data).	Working model is not built.
Redesign	Group uses data to redesign the working model into a more effective bridge. Group clearly and completely documents the results of the redesign.	Group uses data to redesign the working model. Group documents the results of the redesign.	Group uses some of the data and/or minimally redesigns the working model. Group documents some of the results of the redesign.	Group does not use their data to redesign the working model. Group minimally documents the results of the redesign.	No redesign is attempted.
Group Process Book	Process book includes: brainstorming and planning documentation, prototype model testing documentation, plan for redesign, documentation of redesign, and reflective peer interviews for all group members.	Process book includes most of the components required.	Process book includes some of the components required.	Process book includes few of the components required.	Process book in not turned in.

* Examples of data to be evaluated or revised: sturdiness, sizes/lengths, shapes, amount of force used (what are the limitations of the force?), appropriateness of type of bridge for selected location/purpose (should the location, purpose, or bridge design be revised based on the amount of weight/force it can handle?)

BRIDGE BASICS



Beam Bridge: Forces
When something pushes down on the **beam**, the beam **bends**. Its top edge is pushed together, and its bottom edge is pulled apart.

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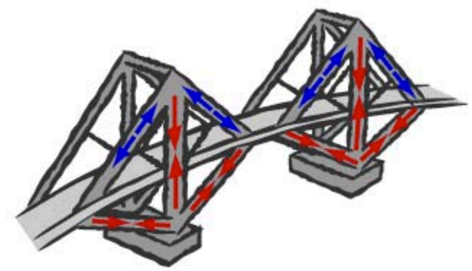

Truss Bridge: Forces
Every bar in this **cantilever** bridge experiences either a pushing or pulling **force**. The bars rarely **bend**. This is why cantilever bridges can **span** farther than **beam bridges**.

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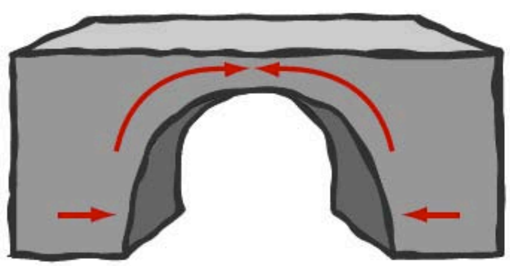

Arch Bridge: Forces
The arch is squeezed together, and this squeezing **force** is carried outward along the curve to the supports at each end. The supports, called abutments, push back on the arch and prevent the ends of the arch from spreading apart.

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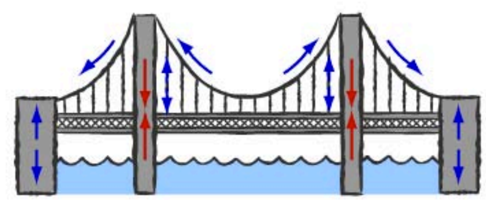

Suspension Bridge: Forces
In all suspension bridges, the roadway hangs from massive **steel cables**, which are draped over two **towers** and secured into solid **concrete** blocks, called anchorages, on both ends of the bridge. The cars push down on the roadway, but because the roadway is suspended, the cables transfer the **load** into **compression** in the two towers. The two towers support most of the bridge's weight.

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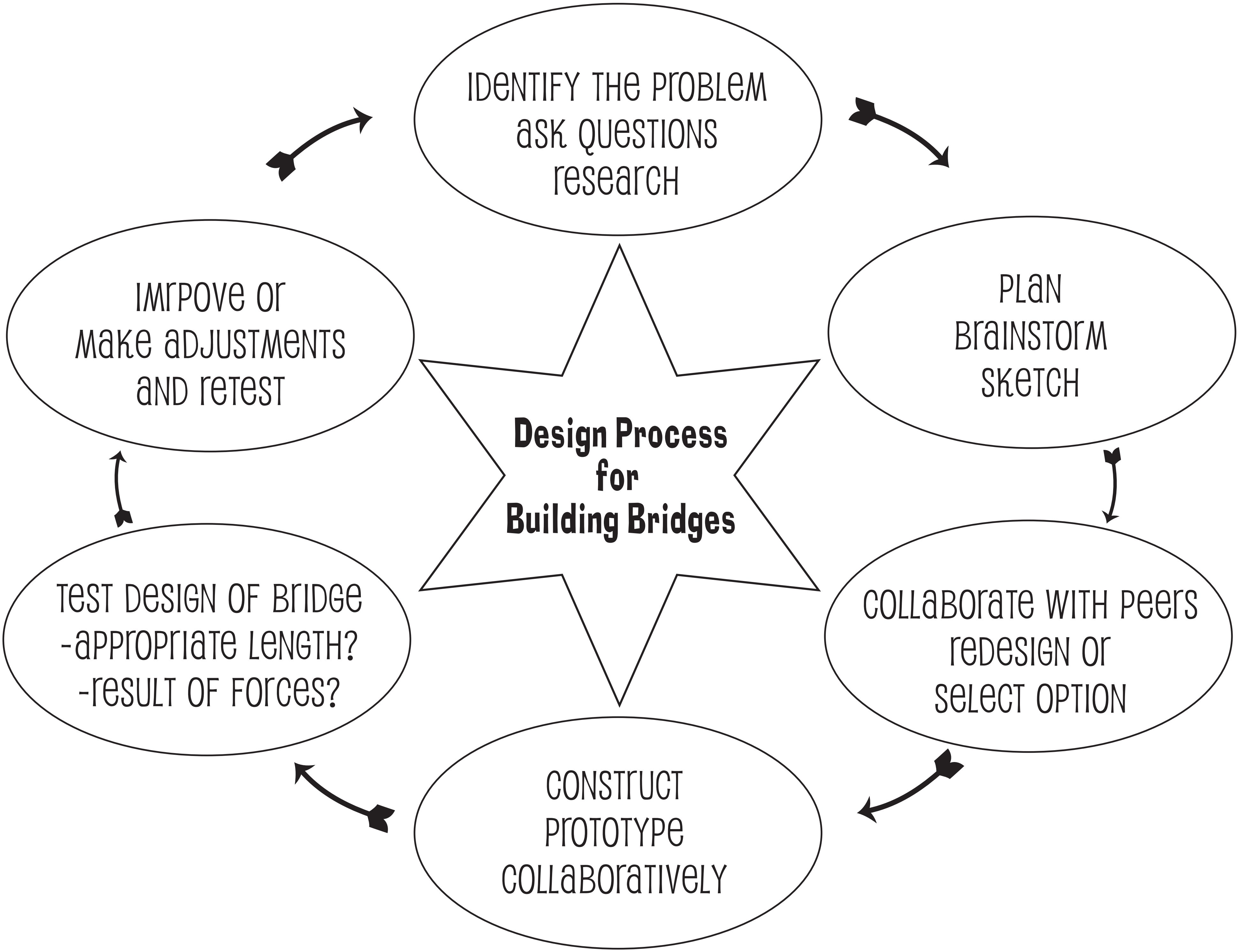
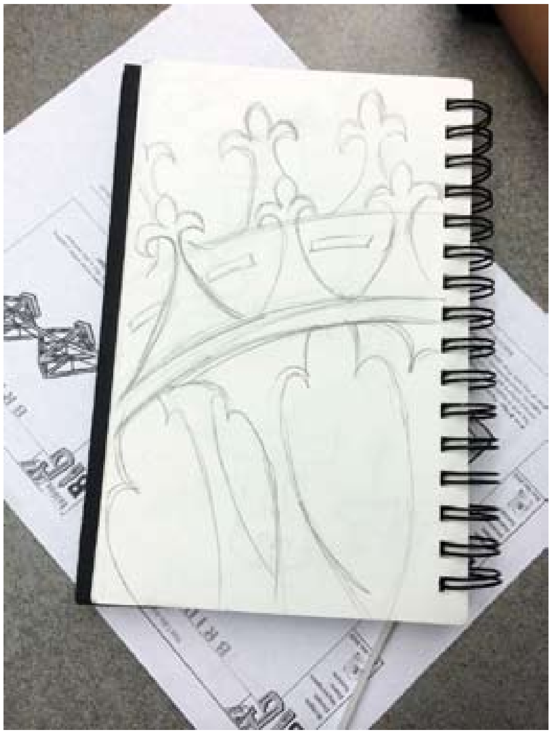
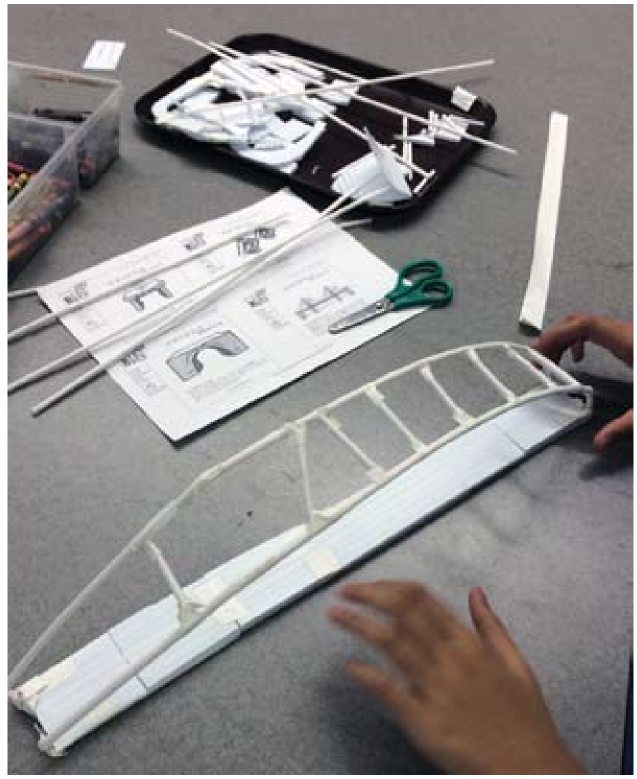
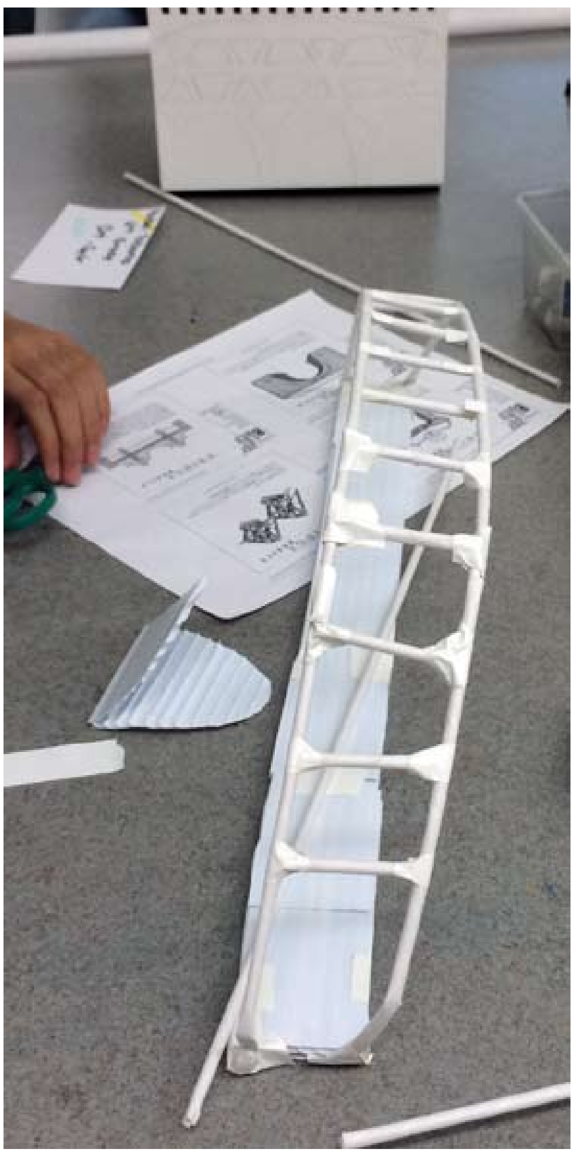
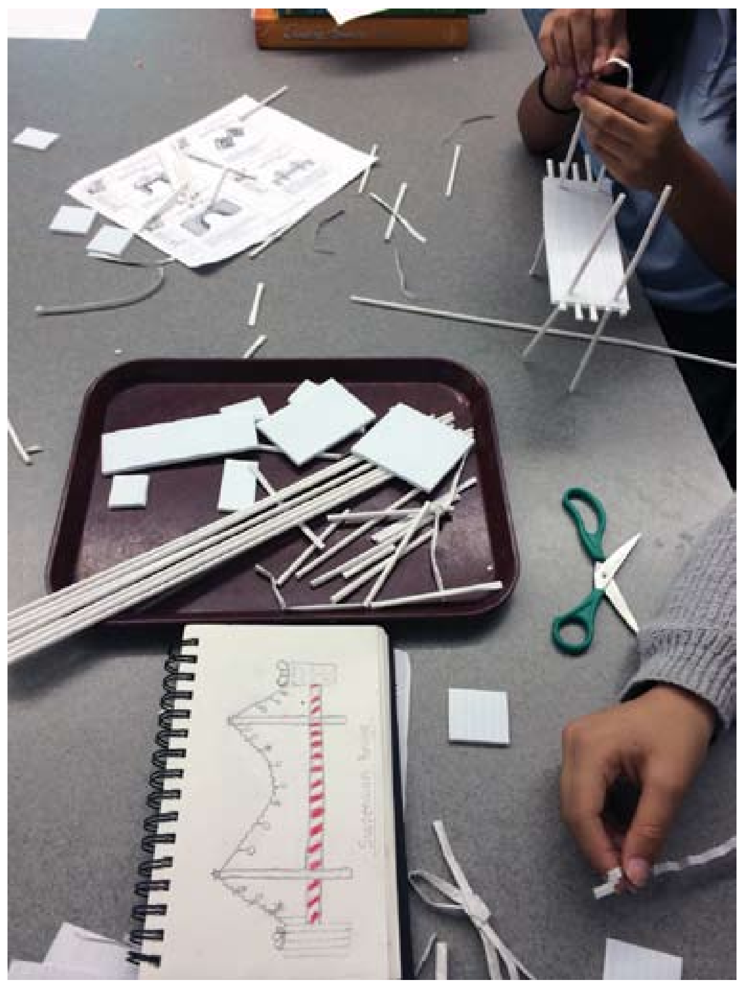

Design Process
for
Building Bridges
Identify the problem
ask questions
research
Plan
Brainstorm
Sketch
Collaborate with peers
redesign or
select option
Construct
prototype
collaboratively
Test design of bridge
-appropriate length?
-result of forces?
Imrpove or
make adjustments
and retest

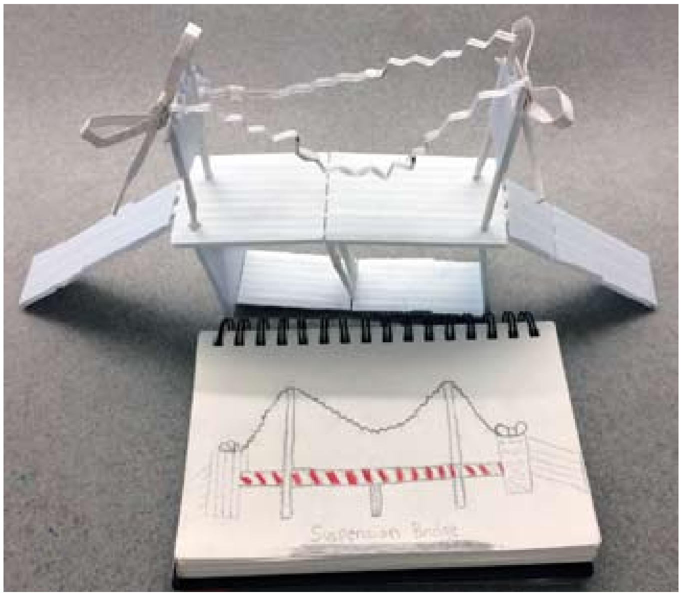


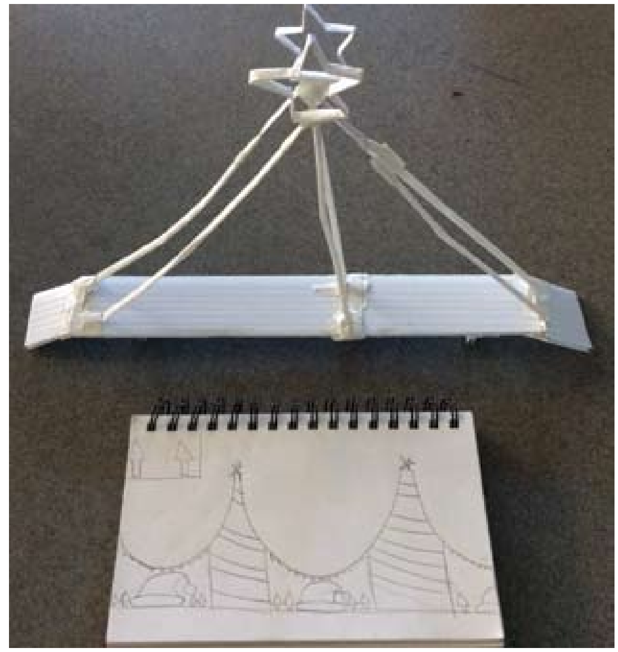


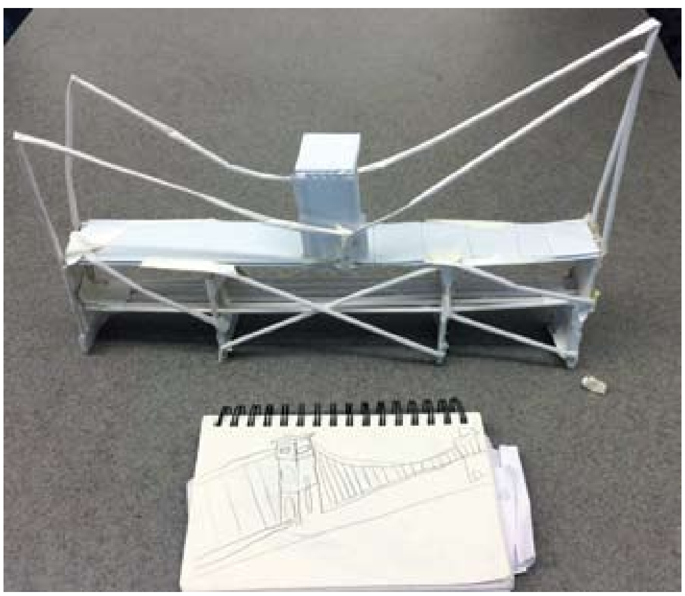


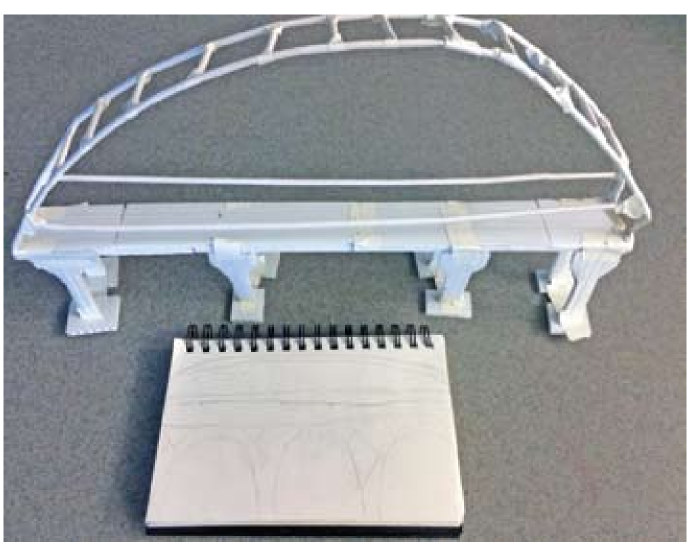


Middle school students collaborating while utilizing the design process









Middle school collaborative bridges utilizing the design process