STEM Title: "Structure" Design Challenge

Grade Level: 2

Duration: Four 45 Minute Inquiry Monday Classes

Objective:	**Focus Concept/s:**
Students will design a container that has the greatest volume.	Structure Design/ Volume
Essential Question/s:	**Connected Benchmark/s:**
How can you create a container with the greatest volume?	SC.2.N.1.6 – Explain how scientists alone or in groups are always investigating new ways to solve problems SC.2.P.8.1 – Observe and measure objects in terms of their properties including size, shape, color, temperature, weight, and texture, sinking or floating in water, and attraction and repulsion of magnets.
Vocabulary: • Manufacturing Engineer • Blueprint • Client • Request for proposal • Prototype • Design Process • Capacity • Pitcher/container • Model	**Suggested Materials:** • Paper • Scissors • Glue • Tape • Sand, dirt, rice (something to fill the container with) • Measuring cups • The Crow and the Pitcher A retelling of Aesop's fable. (Myon.com) • Design Challenge Planning Sheet • Design Challenge Cycle Poster • Request for Proposals Form • Manufacturing Engineer Profile Sheet

Note: The times posted are guidelines to help with pacing. If the students finish a stage earlier than planned, they may continue to the next stage in the cycle.

First Monday- 45 Minutes

Problem/Challenge (Engage):

- Read The Crow and the Pitcher a retelling of Aesop's fable.
  Log-in to Myon.com
  Teacher Log-In: Lawson Number
  Password: two digit month and four digit year
  - In the fable, Crow was proud of herself for not giving up and solving the problem. Once again, Crow is very thirsty and has a new problem. Crow is looking for a team of engineers to create a new pitcher (container) that will have the greatest volume and will hold the most water. Crow has

contacted your teacher, the project manager, to help solve her problem.

- Show and read the Request for Proposals Form (RPF).
  - Discuss with your students:
    Who is your client? (Crow)
    What type of product do we need to create? (A container with the greatest volume)
    What criteria is listed on the Request for Proposal Form? (The container will be made with only one piece of paper, scissors, glue, and tape)
- Refer students to the Design Challenge Cycle (poster) and explain to students that every design challenge begins with a problem. Restate the problem that Crow would like engineering teams to solve.
- Pass out the Design Challenge Planning Sheet and have the students restate the problem in their own words.
- Explain to students that they will become manufacturing engineers. Read the "Becoming a Manufacturing Engineer" Career Profile sheet. Explain that manufacturing engineers design, plan, develop, and improve products. Being an engineer is exciting because we get to use our creative minds to design and build new things. We will have fun being engineers who strive to be creative and work together.
  Teacher Note: Find more information about manufacturing engineers at
  http://www.pike.k12.in.us/schools/nasc/classes/kwallace/types+of+Engineers.htm

Brainstorm/Investigate (Focus Concepts):

- Explain that volume is the amount of space an object takes up. Show several different types of containers you have around the classroom and discuss which of the containers have the greatest volume.
  - Discuss with your students:
    Which container looks like it would hold the most?
    How could we measure which container has the largest volume?
    Which of these containers has the least volume?
- Put students in pairs or triads of engineering teams. Give them a few minutes to start brainstorming together about possible prototypes . They can sketch two possible ideas on their individual Design Challenge Planning Sheet.

Second Monday – 45 minutes

- Have the students get into the groups you assigned on the First Monday. You may want to review your classroom norms for working in groups and fair ways for everyone to share their ideas. Direct the groups to record their brainstorming of two possibilities of prototypes on the Design Challenge Planning Sheet. Although the groups may have come up with several ideas for their prototypes, they should choose only two to record on their sheets. When all students in the group are done, have them share their sketches and discuss the strengths and weaknesses of each design. Discuss with your students:
  Why did your group choose one design possibility over the other?
  How did everyone in the group contribute?

Plan/Design (Blueprint):

- Show students that the next step in the cycle is Plan/Design. As a group, they need to choose one design that they feel best meets the needs in the RFP (Request for Proposal)
- When the engineering teams have made their decision on which prototype idea they are going to move forward with building, they should sketch their blueprint in the space provided on Design Challenge Planning Sheet.
- Encourage engineers to be as detailed as possible, and to keep in mind that they are making a scientific engineering sketch. Their completed sketches should serve as a guide when they get to the building phase. This means that sketches should include labels which list all of the needed

materials. Remind engineers that when they are in the next step (which is to build) that their prototype should match their blueprint as much as possible. Relate this back to real world by pointing out that if an engineer shows a project manager a blueprint of a design, but what they build turns out to look very different, the project manager, may possibly not pay that engineer because they did not provide the structure that the project manager was expecting.

Build /Test: (Students are expected to complete the build on day 2 but not reach the testing stage. Remember these timelines are estimates.)

- Show students that the next step in the cycle is Build/Test. To complete this part of the cycle, the engineers will receive their materials and actually construct their prototypes. Make sure their blueprint has the labeled materials before giving them their supplies.
- Remind engineers that during construction of their prototype, they should refer often to their blueprint to be sure that the design of their prototype is as accurate as possible.
- Once finished, have the engineering teams place their prototypes on display until next Monday.
- If time permits, do a gallery walk so that all engineers may view all prototypes and have discussion about the differences between the prototypes.

Third Monday – 45 minutes

Build/**Test** (start with testing today.): *NOTE: Discuss as a class how you will collect data prior to testing.

- Make a class data collection chart.
- Have engineers prepare to test their prototypes.
- Remind engineering teams that the design challenge focus is the container that can hold the most volume.
- As a class test each prototype by adding rice, sand, or dirt (whichever you have decided to use) to their prototype until the container is full. (Discuss why sand works better than water to test a paper container)
- When their container is full, the material that they have filled their containers with should be poured in to a measuring cup and documented. Students are measuring the total amount of sand, dirt, or whichever material, they were able to fit into their containers.

  *NOTE: It may be easier to weigh the containers once filled with sand to measure which has the most volume (because each container is made with only one sheet of paper, the weight will be based on how much material is put inside).

Collect/Analyze Data:

- Discuss as a class that it is important to collect data to prove which prototype is the best. Refer to the Design Challenge Cycle to highlight that the next step is to Collect and Analyze Data.
- Show students how to create a simple data chart in the Collect and Analyze Data section of the Design Challenge Planning sheet for them to record the data of their group's prototype.
- Be sure all engineering groups are correctly recording their data.
- Continue to test and record data. Ideally, engineers should complete at least five trials with their prototype to show effective data collection. You can record the data on the class data chart and students can write their individual group data on their Design Challenge Planning sheet chart.
- Have a discussion about the results of the data.
  - Discuss with students:
    Which teams of engineers have the most effective prototypes?
    What trends or differences were there between the prototypes?
    Which prototype do you think the client will like the best?

Fourth Monday – 45 minutes
Reflect on Improvements:

- Refer students to the next step in the Design Challenge Cycle, which is Reflect/Improve. Talk with students about how engineers take time to think about their design and what they can do to make it better.
- Give engineers time to turn and talk about what they would do to improve on their design and allow them to share out.
- Remind students that engineers are never finished; they continue to make their design better.
- Direct students to record their reflections on the Design Challenge Planning sheet. These reflections should guide engineers as they work to possibly re-design.
- Allow groups to re-design a prototype to present to the Crow. This part of the process allows students to understand how engineers take time to make their prototypes even better before submitting.
- When re-designing, students will collect and analyze data again, then reflect on their prototypes once more. When going through a re-design, have students record their data and reflections with a colored pencil so that they are able to see easily the difference between their first prototype and their second attempt.
- Engineering teams should now prepare for the next step, which is to prove to the Crow why their prototype is the best.

Evaluate/Justify:

- Show this step on the Design Challenge Cycle poster and explain to students that in this step, several prototypes are evaluated. Engineers must justify why their prototype is the one that should be selected by the Crow.
- Give engineering teams time to talk about what they will say to justify their prototype.
- Engineers should use evidence from the data collected to support their justification.
- Allow engineers to use the "evaluate and justify your answer" section of the design challenge planning sheet as a guide prior to presenting their prototypes.
- Groups should present their prototypes to you (project manager) one at a time so that all engineers may benefit from hearing the explanations of the others. After all prototypes have been shared, engineers might now have further ideas about re-design! You can point out to students that this is why our design challenge works in a cycle!
- Remind students to keep thinking like those engineers and get ready for our next design challenge!

MECHANICAL ENGINEER PROFILE

As a mechanical engineer, you might develop a bike lock or an aircraft carrier, a child's toy or a hybrid car engine, a wheelchair or a sailboat—in other words, just about anything you can think of that involves a mechanical process, whether it's a cool, cutting-edge product or a life-saving medical device. Mechanical engineers are often referred to as the general practitioners of the engineering profession, since they work in nearly every area of technology, from aerospace and automotive to computers and biotechnology.
http://www.discoverengineering.org/

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Request for Proposal

Proposals must be submitted as a model.

The Crow is very thirsty. She is hiring your team of engineers to create a new container that will have the most volume. You will get one piece of paper, scissors and glue to create your container. You will then test your prototype, by filling it with sand (rice, etc). The container that holds the most will be the one that the Crow wants.

Will your team of engineers win the bid for having the container that holds the most volume?

Engineer _____

Teacher: Provide one copy of this page for each student or use student notebooks for planning. (Day 1)

Design Challenge Planning Sheet

Problem/Challenge:

_____

_____

Investigate/Brainstorm: *Draft possible solutions.*

A.

B.

Select the solution you plan to build. What are the strengths and weaknesses of your design? How will it help you complete your proposal?

_____

_____

Teacher: Model using this page. Students will complete this page in teams in future Challenges

Plan/Design: Sketch your blueprint & label the parts.

Build/Test: Build and then test your design.

Collect and Analyze Data:

Data Chart	
Trial 1	
Trial 2	
Trial 3	
Trial 4	
Trial 5	

Reflect /Improve: What could we have done to make our design better?

Evaluate and Justify: Share your design with the class and explain why you think it is the best design.