**Title:**

Engineering Design Process: Whatever Floats Your Boat

**Grade Level(s):**

2nd Grade

**Theme:**

Constructing Explanations and Designing Solutions

**Objective:**

Students will be able to explain the difference between the disciplines of science and engineering.

Students will be able to apply the engineering design process as a means to investigate the properties of different materials to successfully float a boat that will support pennies.

**Learning Targets**

I can *explain* why different materials have properties best suited for creating a boat that floats in water while keeping pennies afloat *(SCIENCE).*

I can implement the engineering design process to design a solution for a model boat with at least two trials *(ENGINEERING).*

**Disciplinary Core Ideas:**

[**PS1.A**: Structure and Properties of Matter](http://www.nap.edu/openbook.php?record_id=13165&page=106).

[Different properties are suited to different purposes.](http://www.nap.edu/openbook.php?record_id=13165&page=106)

**Science and Engineering Practices:**

Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.

Analyze data from tests of an object or tool to determine if it works as intended.

**Engineering Design Standard(s)**

**K-20-ETS1-1**. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

**Constructing Explanations and Designing Solutions**

Apply scientific ideas to solve design problems.

Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution

**Performance Expectation**

**2-PS1-2** Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.\* [Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.] [Assessment Boundary: Assessment of quantitative measurements is limited to length.]

**Materials:**

Engage:

Book: Who Sank the Boat?

During the Activity (available to participants for boat construction):

* Foam meat trays (cut into 4\*4 inch squares)
	+ 2 per bundle
* Straws (bendable)
	+ 2 per bundle
* Toothpicks
	+ 6 per bundle
* Popsicle sticks (small)
	+ 2 per bundle
* Scotch tape
	+ 6 inches per bundle
* Rubber bands (medium)
	+ 2 per bundle
* Bubble wrap, small bubbles (cut into 4\*4” squares)
	+ 2 per bundle
* Aluminum foil (cut into 4\*4” squares)
	+ 2 per bundle
* Wax Paper
	+ 3 per bundle
* Aluminum foil (3\*3” squares)
	+ 4 per bundle
* Wax paper (3\*3” squares)
	+ 4 per bundle

**Procedures:**

Part 1:

* Slide #2: Ask the prompt: *“What are some of the main differences between science and engineering (or scientists versus engineers)? You may also list any similarities, but for now, focus on the differences “Give the participants at least 3 minutes to brainstorm individually. Allow them to share with the table, followed by a group share session.*
* Slide #3: Emphasize the differences between science and engineering. Focus on the fact that science starts with a question and, in various forms and fashions, works towards an answer. In engineering, the predetermined product (or process) is chosen and steps are taken to meet that goal.
* Use appropriate slides to explain the definition of an engineer and the engineering design process.

Part 2:

**Intro:**

* Ask if the students have had any experiences being in a real boat or playing with a toy boat before.
* Share out loud with raised hands.
* Slide 4: Show the scanned front cover of the book. Ask students what they think the book is about.
* Read the book using the scanned PPT pages. Stop at various points to have the students predict what they think will happen on the next page. Have the students explain why (such as the cow is big, it will make the boat sink, etc.).

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| Engineering DesignProcess Steps(Boston Museum of Science Model) | Description of Step |
| Ask | * Challenge: Slide #27. Create a better boat so our animal friends can make it across the bay. Design a boat to hold the most amount of weight possible (pennies).
* Slide #30. In order to officially do the Ask stage, allow participants to ask questions such as:
	+ What types of materials can we use?
	+ How long do we have?
	+ Where will it have to float?
	+ etc…
	+ Record responses on chart paper (2 pieces on wall) or type into Word document on projection screen. *This must be done very efficiently so as not to use too much time. Place a 4-5 minute limit on it.*
* Allow the students to have a short amount of time to investigate the materials they will be using. Be sure you have them **construct explanations** regarding both the types of materials they wish to use and why those chose them.
* Share with them how much a penny weighs (2.5 grams, about the mass of 2 and-a-half large paper clips.
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| Imagine | * Slide #31. Give the students time to think of the various ideas of boats they may have. If they have learned about sinking and floating in the past, encourage them to think of any key terms or concepts.
* PPT slide #10. Show the students the Imagine slide. Have EACH student draw three models of the boat they think they can build in their journals. *“This is a brainstorm. There is no judging and the students will not share at this point.”*
* This must be completed both *individually and quietly*.
* Remind them that this is one of the most important steps/aspects of engineering.
* Teacher should walk around making sure every student completes at least 3 drawings. Encourage them to label their drawings.
* Provide any guidance, if needed
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| Plan | * Slide #32. Have all group members share out their ideas with their group. *“What are some things that are the same? Different?”*
* The group must now compromise and come to a consensus on ONE final plan. Everybody must include that plan in their journals.
* The teacher must be active in making sure the students are working together as a team, compromising, and working towards a plan. If the teacher wishes, he or she can entice the groups with an extra “token” to ensure good collaboration for the engineering team.
* The students will create a list of the materials they need based on their budget of 8 tokens.
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| Create | * Slide #33. Allow students 10 minutes to work on their boat models. Use a timer that is visual to the participants (TeamTimer).
* Once they are finished, they will need to get a thumbs-up from the teacher so they can go try their boats. The teacher will add pennies until the boat sinks. The teacher will have two pans of water to have boats going one-after-another.
* Groups can come up and test. The teacher will add the pennies until the boat sinks. The students must record this in their journals.
* The teacher will provide two more tokens for each group to purchase any needed supplies (which will be in addition to their initial materials).
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| Improve | * Slide #34. Using their prior designs, and the results from the challenge, students will get 8 minutes to improve their boats one more time. Once the students draw their new plans in their journals, they will get a thumbs-up from the instructor. They can then try their boat products again to compare results.
* This can be treated as a contest as if the teacher is looking for an engineering firm that builds the best boat.
* The groups will share out their designs together, comparing which designs and materials tended to work best (refer them back to the standards for 2nd grade properties of matter standards and K-2 Engineering Design standards).
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* Use Slides 36-39 to share the relevant standards (Grade 2 – Properties of Materials and K-2 Engineering Design).

**Evaluate (Rubric):**

**Language Arts Extension:**

During the next class period, the students will get one page in order to represent that last page of the book that will show what they think is on the other side of the harbor for the donkey, pig, sheep, and mouse, along with what they had to do to get there. The students can illustrate the page and write a short narration to describe what was on the other side, incorporating how their new boat design allowed them to cross the bay.

**Common Core State Standards Connections:**

ELA/Literacy –

W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-PS1-1),(2-PS1- 2),(2-PS1-3)

**Mathematics –**

MP.2 Reason abstractly and quantitatively. (2-PS1-2)

MP.5 Use appropriate tools strategically. (2-PS1-2)