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Grade 3-5 STEM Challenge

Boats That Float

Inspired by Matt, a Mechanical Engineer in the Indiana Uplands.

Published by Regional Opportunity Initiatives

GRADE 3-5 STEM CHALLENGE

Boats That Float

Inspired by Matt, a Mechanical Engineer in the Indiana Uplands.

Students will design and build a boat that can remain floating while carrying a load.

CAREER CONNECTION AND LESSON OVERVIEW

Matt is a mechanical engineer at the NSWC Crane in southern Indiana. An engineer is someone who designs and builds complex products, machines, systems, or structures. As a civilian employee, Matt designs, builds, and repairs sensor systems that go on Naval ships, vehicles, and aircraft. Engineers want to know how and why things work and mechanical engineers focus on designing physical tools and equipment, like Matt's sensors.

In this activity, students will design, build, and test small boats out of common supplies. Their boats must be able to not only float but carry materials without sinking. Like real engineers, students will need to test and refine their designs to find solutions!

LESSON TIMELINE

DAY 1 60 Minutes

- Show the inspiration video, "Matt - Mechanical Engineer"
- Complete page 1 of the Engineering Design Process handout

DAY 2 60 Minutes

- Create a boat design
- Test prototypes
- Improve designs

DAY 3 60 Minutes

- Share out boat designs
- Communicate successes and challenges

Recommended Supplies

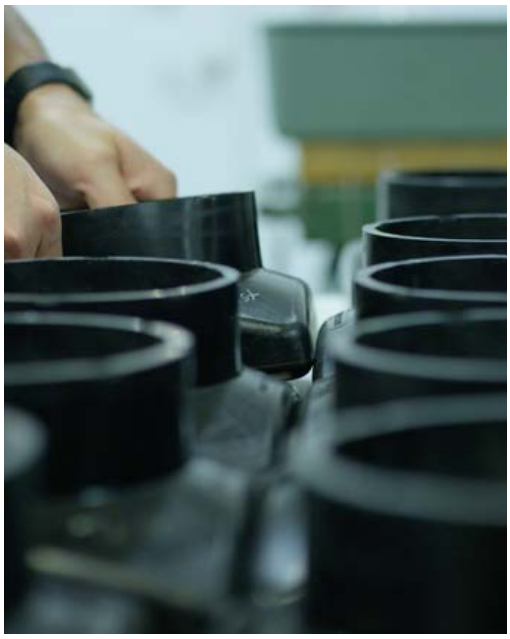
For the class:

- Foil
- Plastic wrap
- Straws
- Popsicle sticks
- String
- Small paper cups
- Small plastic or styrofoam cups
- Construction paper
- Additional assorted supplies as needed

Students will need a bin or basin of water to allow groups to test their boat designs.

For each group:

- 10 Unifix cubes per group
- Tape
- Scissors



IN THIS CHALLENGE, STUDENTS WILL:

- Explore the Engineering Design Process by designing and building a boat that will float while loaded with "supplies."
- Test and improve their boat designs.
- Share their prototypes and revised designs with the .

Standards

Science & Engineering Process Standards

SEPS.1 Posing Questions (for science) and defining problems (for engineering)
SEPS.2 Developing and using models and tools
SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)
SEPS.8 Obtaining, evaluating, and communicating information

Engineering Standards

3-5.E.1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.
3-5.E.3 Construct and perform fair investigations in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

English/Language Arts

3.SL.4.2 Create oral presentations that maintain a clear focus, using various media when appropriate to emphasize or enhance certain facts or details.
4.SL.4.2 Create oral presentations that maintain a clear focus, using multimedia to enhance the development of main ideas and themes that engage the audience.
5.SL.4.2 Create engaging presentations that include multimedia components and visual displays when appropriate to enhance the development of main ideas or themes.

Computer Science Standards

3-5.PA.1 Use technology resources for problem solving and self-directed learning, general-purpose productivity tools and peripherals to support personal productivity, remediate skill deficits, facilitate learning, and individual/collaborative writing, communication and publishing materials.
3-5.NC.2 Use productivity technology tools for individual and collaborative writing, communication and publishing activities.

Math Standards

3.C.1 Add and subtract whole numbers fluently within 1000.
3.AT.1 Solve real-world problems involving addition and subtraction of whole numbers within 1000.
4.C.1 Add and subtract multi-digit numbers fluently using a standard algorithmic approach.
4.AT.1 Solve real-world problems involving addition and subtraction of whole numbers.
5.C.1 Multiply multi-digit while numbers fluently using a standard algorithmic approach.

Extension: Science Standards

4.PS.4 Describe and investigate different ways in which energy can be generated and/or converted from one form of energy to another form of energy.

Employability Skills Standards

3-5.WE.4 Complete tasks or activities with prompting and guidance from adult educators.
3-5.WE.5 Demonstrate perseverance to complete tasks and activities.
3-5.LS.2 Communicate with others by applying a variety of speaking skills.
3-5.LS.3 Communicate with others using a variety of technology.
3-5.LS.4 Relate personal interests, abilities, and leisure time activities to possible occupational choices without stereotyping.
3-5.LS.8 Develop criteria for making decisions and predict results of choices to find the best solution.
3-5.LS.10 Identify a short-term goal and develop a plan of action.
3-5.LS.13 Utilize effective questioning and brainstorming techniques.

Planning and Implementation

BOATS THAT FLOAT

Essential Vocabulary

- MECHANICAL ENGINEERING: The branch of engineering dealing with the design, development, construction, testing, and use of machines and other mechanical devices.
- ELECTRICAL ENGINEERING: The branch of engineering dealing with the study, design, and practical application of electrical systems and electronics.
- CIVIL ENGINEERING: The branch of engineering dealing with the design and construction of infrastructure and systems like bridges, dams, tunnels, sewer and water.
- CHEMICAL ENGINEERING: The branch of engineering dealing with chemical production and the manufacturing of products using chemical processes.
- INDUSTRIAL ENGINEERING: The branch of engineering dealing with the study, design, and improvement of systems to help companies make a product or provide a service.
- PROTOTYPE: a first model of something from which other models are developed or copied.

In this challenge, students will:

- View the job shadow video "Matt-Mechanical Engineer," available at https://regionalopportunityinc.org/matt/.
- Design and build a boat that will float while loaded with ‘supplies’ (Unifix cubes).
- Test and improve their boat design.
- Share their prototype and Engineering Design Process by documenting the steps they took to get to the finished boat.
- Optional Extension: Students will adjust designs in response to included scenario cards, adding unexpected constraints to the challenge.

Before Class:

- Read the lesson plan to become familiar with the activity.
- Gather necessary materials. Students will need a class pool of materials to choose from for their designs. Each working group should have their own scissors and tape.
- Fill at least one large sink, basin, or waterproof storage bin with 8-12" inches of water for boat testing. This activity can get messy so drop cloths or trash bags laid out in the "splash zone" are helpful if this activity is done indoors.
- Edit "Boats That Float" Price List if needed.

Day 1

Introduction (20 Minutes)

Introduce students to the field of engineering and the types of questions engineers answer. Pose the question to students:

> "What do you know about engineering or being an engineer?"

Explain that the person in the video they will watch today is a mechanical engineer. Matt works for NSWC Crane which is a division of the United States Navy located in southern Indiana.

Explain that mechanical engineering is the broadest area of engineering. Other areas of engineering include electrical engineering, civil engineering, chemical engineering and industrial engineering. Either project the Mechanical Engineering career profile or give a copy to each student. Here they can read more about Matt's work.

Once students are familiar with what an engineer does, show "Matt- Mechanical Engineer" available at https://regionalopportunityinc.org/matt/ (4:00).

Students will be working in groups of three for this challenge. Within their group, they should choose a Building Lead, a Materials Manager, and a Recorder.

- The Building Lead will make sure that every group member's ideas are heard and that each group member contributes to constructing the boat. The building lead will also handle the boat when it is time to test the prototype.
- The Materials Manager will gather and organize materials the group has chosen for construction. The materials manager will observe during prototype testing.
- The Recorder will make sure that the group's ideas are recorded during the Imagine stage and will observe and record details of what takes place during prototype testing. These observations will help the group when making improvements.

Students will begin the study of Matt's job by using the Engineering Design Process to create a boat that will carry a large amount of supplies for the Navy. The boat must be able to not only hold the supplies, but also remain stable in wind and waves. For this challenge, the 'supplies' will be represented by 10 unifix cubes.

Ask, Imagine, Plan (40 Minutes)

Introduce the challenge to the class: Students will have a selection of materials with which to build a boat. This boat must:

- Float
- Hold a load (Unifix cubes or other blocks)
- Be guild on a pre-agreed budget

Provide students with the budget they will be allowed. $20 is a good starting point but this can be increased or decreased based on your students. The materials list provides recommended costs for each material.

Encourage students to think about:

- What characteristics does a boat need to carry a large amount of supplies?
- What design elements increase a boat's stability in the water?
- How can we design and build a stable boat that will carry the Navy's supplies?

Have the students discuss these questions within their groups and record their answers the ASK box on their Engineering Design Process Sheet.

Introduce the building materials that will be available to the students and the budget for the project. Suggested materials are listed on the overview page of this lesson plan. In their small groups, allow students time to sketch a few designs of their boat in the IMAGINE box on their Engineering Design Process Sheet.

As students work, prompt them to brainstorm solutions to issues they may run into. For example,

- What might happen if a strong gust of wind hits their boat?
- How would materials affect the strength of their boat design?

Finally, prompt students to discuss their ideas and agree upon a plan for their boat design. They will record the plan in the PLAN box on their Engineering Design Process Sheet and complete the budget.

Day 2

Create and Improve (60 Minutes)

Using their plans from Day 1, small groups will build their boats and complete the CREATE box on the Engineering Design Process Sheet. As each group completes their boat design, they will test their prototype in the provided body of water (sink, basin, bin, etc. of water.)

In each round of testing, students should ask:

- Did the boat float?
- Did the boat float when the 'supplies' (10 Unifix cubes) were placed upon it?
- Did the boat float despite the wind (fan the testing area with a folder)?
- Did the boat float despite the waves (from the teacher gently shaking the testing bin)

Optional Extension: Provide students with challenges from the Scenario Cards on page S5 to add additional complications to their designs.

Following testing, each group will reflect on the improvement process by brainstorming ways in which their prototype could be improved upon and completing the IMPROVE box on their Engineering Design Process Sheet.

Students should continue the Test/Improve cycle until they have a model that successfully passes the test and comes in at or under the budget they were given.

Day 3

Communicate (60 Minutes)

Students will work in their small groups or individually to complete the COMMUNICATE box on their Engineering Design Process sheet.

Have students use available technology (or another mode of communication) to summarize their STEM Challenge. Presentations should include:

- a summary of what students learned about engineering a boat.
- a summary of the information in the CREATE and IMPROVE boxes
- description of the test(s) conducted
- the most successful and the most difficult part of this STEM challenge.

Career Exploration and Extension

Prompt students to think about and research what a career as a mechanical engineer might involve.

- What does a mechanical engineer do all day? What does Matt do?
- What kind of education would a student need to become an engineer?
- What are the different kinds of engineers?

Name: _____

Boats That Float

Engineering Design Process Sheet

ASK

What is the problem we are going to solve?

IMAGINE

Brainstorm solutions to the problem above.
Record your ideas in words or pictures.

Name: _____

PLAN

Create a blueprint of the prototype you will build.
What materials will you use?

Budget Sheet

Item	How many?	Total Cost
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

CREATE

You will have _____minutes.
Use this time to build the prototype you planned.

Describe the model you created.

_____

_____

_____

How much money do you have left in your budget for improvements?

_____

Name: _____

IMPROVE

Edit the prototype that your group made.

Explain the changes that your group made to your model.

Why did your group make these changes?

COMMUNICATE

Share your prototype with the class or another group.

What was the most difficult part of this challenge?

What was the most successful part of this challenge for your group?

Name: _____

Boats That Float

Price List

Supply Price List	
Item	**Price**
Foil (12 inch square)	$7.50
Plastic Wrap (12 inch square)	$7.25
Cup	$5.00
Straw	$2.33
Popsicle Stick	$2.50
String (1 foot)	$4.50
Tape (1 foot)	$3.55
Additional Items:	**Price**
_____.	_____
_____.	_____
_____.	_____
_____.	_____
_____.	_____

Name: _____

Boats That Float

Additional Scenario Cards

Your budget has been cut... You must **reduce** your budget by $5.00.	**Your budget has been cut...** You must **reduce** your budget by $5.00.
Delayed Shipment! The shipment of cups has been delayed. **Remove** any cups from your design.	**Delayed Shipment!** The shipment of cups has been delayed. **Remove** any cups from your design.
New Bridge Construction! A new bridge is being built. Make sure your design is no more than **5 inches** tall.	**New Bridge Construction!** A new bridge is being built. Make sure your design is no more than **5 inches** tall.
Change of plans... The Navy needs additional supplies. Increase the load to **15 Unifix** cubes. *You may add $5 to your budget!	**Change of plans...** The Navy needs additional supplies. Increase the load to **15 Unifix** cubes. *You may add $5 to your budget!

ACKNOWLEDGEMENTS

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IMAGE AND CONTENT CREDITS

Images

Stock photography courtesy of Canva.com

Still video images from "Matt - Mechanical Engineer," available at https://regionalopportunityinc.org/matt

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