THE UCONN-URI NAVY STEM COALITION

EDUCATOR'S GUIDE
2ND - 8TH GRADE EDITION

NAVY STEM CREW
EST. 2017

ADDRESSING ENGINEERING WORKFORCE NEEDS IN THE NAVAL SECTOR

Table of Contents

Overview

The UConn-URI Navy STEM Coalition is supporting the Navy's multi-generational effort to rebuild the submarine fleet through the ANCHOR (Advancing Naval Careers through Higher-Ed Outreach and Research) program. By establishing a K–16 Navy STEM education and training pipeline, the Coalition addresses the workforce needs of the submarine community in Connecticut and Rhode Island, as well as the broader Maritime Industrial Base nationwide. The Coalition closely coordinates its initiatives with General Dynamics Electric Boat and Buildsubmarines.com to maximize impact and ensure a steady talent pipeline.

For more information on our program, visit us at:
https://navy-stem.uconn.edu/

Program Introduction

Our UConn-URI Navy STEM Coalition has a mission to bring naval engineering concepts and excitement to students across the nation. We are a group of undergraduates, graduates, and professionals from the University of Connecticut and the University of Rhode Island, united by a passion for engineering education and all things Navy! We have developed three hands-on activity lessons that promote creative thinking, engineering with a purpose, and topics relevant to our mission. Our goal is to engage students in team-oriented activities that allow them to practice and strengthen their skills in science, technology, engineering, and math. There is no right or wrong way for students to design their projects, so please encourage creativity and thoughtful design choices and let's see what these junior engineers can come up with!

Lesson Outline:

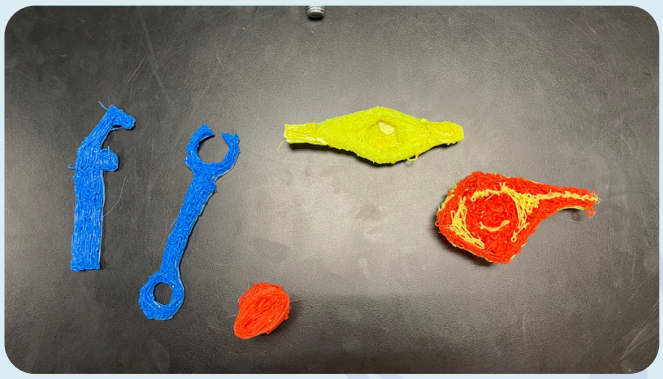
- **Lesson 1 - Additive Manufacturing** - Students learn about the additive manufacturing process as they attempt design and build challenges using 3D pens.

- **Lesson 2 - Build a Boat** - Students learn about buoyancy, load stabilization, and engineering design for a purpose while they design and construct their own boat.

- **Lesson 3 - Build a Submarine** - Students learn about material science and engineering while they design and construct their own submarine.

Lesson Images

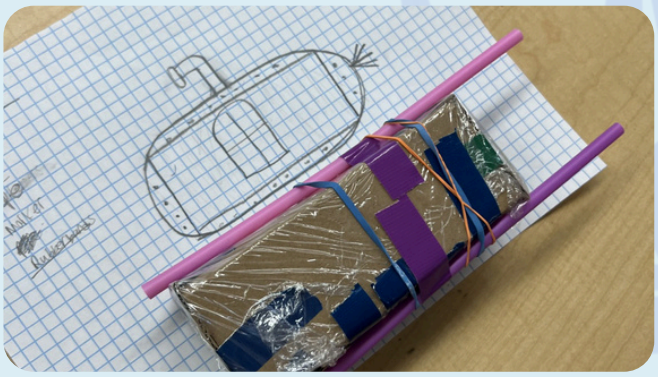
Additive Manufacturing: 4th-8th



Tools designed by 8th graders to manipulate screws

4th grader learning to use a 3D pen

Build a Submarine: 2nd-8th



4th grade submarine design

“Build a Boat” materials store open for business

Build a Boat: 2nd-8th

Boat weight testing in progress

A boat under construction in a middle school classroom

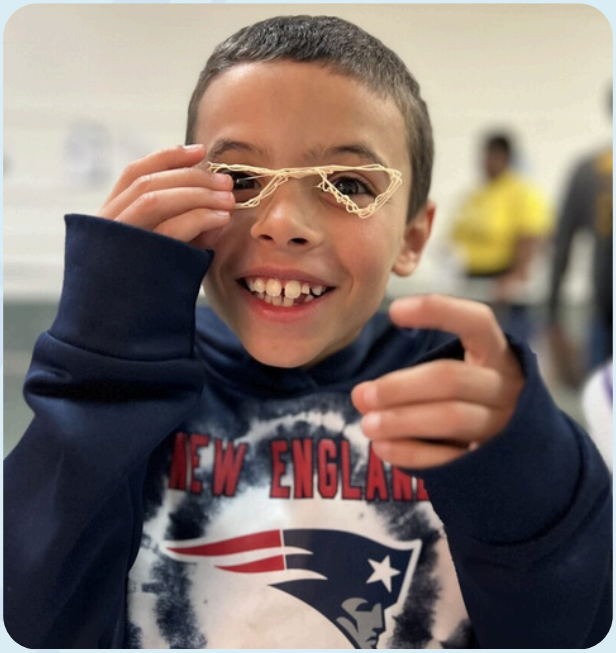
Additive Manufacturing

Lesson Plan

Importance:
As the field of additive manufacturing grows, the DoD and the Navy will rely on additive manufacturing technologies to fabricate parts of our ships, planes, etc. While there is currently a limited application of these technologies, we can anticipate that the future will heavily depend on additive manufacturing!

Recommended Grades:
4-8

NGSS:
3-5-ETS1 Engineering Design
MS-ETS1-1 Engineering Design



Length:
Approximately 1 hour

Materials:
-3D Printing pen(s)
-Printing mats
-PLA filament
-Paper
-Pencil
-Ruler
-Nuts and bolt - recommended 1-2" in size

Supplemental materials:
UConn Navy STEM Crew Additive Manufacturing PowerPoint for classroom use

Additive Manufacturing

Lesson Plan

Procedure
Pre-plug in pens or know they will take 5 minutes to warm.

Activity One: Load Structure (approx. 15 minutes)
Teams must first draw a design on paper to plan how they will build their structure to fit the design parameters below (change as you see fit).
Students must develop a structure where:

- The structure is at least 3" tall.
- The structure is free standing.
- Can hold the weight and size of something equivalent to a cell phone.

Activity Two: Height Structure (approx. 15 minutes)
Teams must first draw a design on paper to plan how they will build their structure to fit the design parameters below (change as you see fit).

- The structure is free standing
- The structure is as tall as possible

Activity Three: Design a tool (approx. 20 minutes)
Allow teams to select a bolt and nut. Teams must first draw a design on paper to plan how they will construct a tool to screw the nut onto the bolt or bolt into the nut.
Guide them to consider the depth, complexity, and scale of their design.
Allow teams time to construct their tool.
As teams complete their tools provide them the opportunity to utilize a test and determine efficacy.

Closing: Facilitate discussion about 3D pens, design processes, and design considerations.

- Could you turn your nut or bolt using your manufactured tool?
- What strategies worked best for designing? For building?
- What improvements could you make?
- Can we talk more about how the Navy will benefit from this technology?
- What do you think additive manufacturing will look like in 5 years? 15 years?
- How can you see if potentially making the world a better place?

Build a Boat

Lesson Plan - Page 1

Importance:
This activity challenges kids to think intuitively to design and construct different boats utilizing concepts of vessel design. Testing helps teach them to make connections between different building materials, buoyancy, and to work together to reach their objectives with problem-solving, troubleshooting, and planning.

Recommended Grades:
2-8

NGSS:
K-2-ETS1-1, Engineering Design
3-5-ETS1 Engineering Design
MS-ETS1-1 Engineering Design

Length:
Approximately 60-90 minutes

Materials per team of 2-3:
-Sketching paper and pencil
-Cardboard, roughly 12"x16" sheets
-Straws
-Disposable plastic cups
-Plastic sandwich baggies
-Popsicle sticks
-Saran wrap
-Masking tape
-Scissors
-Storage bin, pitcher, and 8" of water for testing
-Weights for testing
-Paper towels

Middle school scale up materials:
-Balloons
-Wax paper
-Ping Pong balls
-Rubber Bands
-Duct tape
-Hot glue gun

Build a Boat

Lesson Plan - Page 2

Challenge: Put on your engineering hard hats kids and help us build a boat that can carry cargo! We need you to put your creativity and knowledge about how things float to work here.
Goal number 1 – Build a boat that floats!
Goal number 2 – We want it to hold the most amount of weight possible!

Procedure:
Start with discussion and adjust based on age:

- Who here knows what a boat is?
  - The meaning of BOAT is a vessel for travel on water.
- What can boats be made out of?
  - Wood, fiberglass, steel, or aluminum.
- What makes a boat go?
  - Paddles (human power), sails (wind power), or engines (mechanical power).
- Have any of you ever been on a boat?
- Besides a boat, what are some things you know that float in water? What are some things that sink in water?
- So how do we think big heavy metal boats that weigh so much can float?
- What do you guys know about engineering?
  - Engineering is the work of an engineer or the study of using scientific principles to design and build machines, structures, and other things.
  - If you want to be an engineer someday and build boats for a job, you can! People build boats every day.
- What do you think those boat engineers are thinking about when they're designing and building boats? What's important?
  - That it floats! That it can stay balanced when it is hit with weather and waves!

Display materials

We want you to design and engineer your own boats to meet the two goals!

Note: Don't show them what the weights look like. Ideally, we want them to think to ask, or we can use as a teachable moment about thoughtful questions in the wrap up.

Build a Boat

Lesson Plan - Page 3

1. Get into groups of 2-3
2. Grab paper and pencil and start designing a blueprint! Remember your goals.
3. Have a teacher review the design and ask “why’d you choose…” and “tell me about…”
4. Have the team approach the “store” for materials that match their design.
    a. Please consider bringing the materials over to the water and allowing them to interact with the water and the materials so they can see how that works. After, suggest they review their blueprint for changes. Functionality over design preferences.
5. Announce build time - approx. 30 minutes
    a. When kids are pretty far into the building, ask them about where they will put the weight on the boat. Have you thought about balance?
6. Complete design and ask the teams to gather around the water bin.
7. See if it floats!
8. Add weights! Max them out until they capsize or take on high amounts of water.
9. Closing discussion:

- Did you enjoy being boat building engineers?
- Think about the boat shapes you saw today – what worked best?
- What didn’t work so well?
- Follow with “why” question to their answer.
- How would you change your boat for next time to improve?
- Did anyone think to ask about the weights we were going to use while designing?
- Why would this be good to know before building?

Words to work into conversations:
Engineering, balance, waterproof, blueprint, buoyancy, hydrodynamics, hull, pontoon, ballast tanks, capsize, stability, load, weight bearing.

Build a Boat

Lesson Plan - Page 4

Middle school scale up-

As with real life ship design and construction, builders are faced with complicated challenges pertaining to budget and available materials. We've added an additional challenge to our hands-on build a boat activity where students are tasked with building their load carrying vessels and trying to minimize build cost in order to be considered a success.

- Pages 13 & 14

Cost Sheet - Middle School

Unit Cost	Build Material
$0.75	Straw (3 pcs)
$1.00	Cardboard
$0.25	Plastic Bag
$1.00/yard	Wax Paper
$1.00	Plastic Cups (2 pcs)
$2.50	Popsicle Sticks (7 pcs)
$2.00/yard	Plastic Wrap

Unit Cost	Fastening Material
$0.25	Rubber Bands
$2.00/yard	Plastic Wrap
$2.50/yard	Duct Tape
$1.25/yard	Masking Tape

Bill of Materials - Order

Max Cost: $

Team Name: _____

Part Name	Quantity	Cost	Total Cost
		$	$
		$	$
		$	$
		$	$
		$	$
		$	$
		$	$
		$	$
		$	$
		$	$
		$	$
Total Build Cost			$
Amount Under Budget			$

Build a Submarine

Lesson Plan - Page 1

Importance:
This activity challenges kids to think intuitively to design and construct different vessels utilizing concepts of material properties. Testing helps teach them to make connections between different materials as parts of equipment and to work together to reach their objectives with problem-solving, troubleshooting, and planning.

Recommended Grades:
2-8

NGSS:
K-2-ETS1-1, Engineering Design
3-5-ETS1 Engineering Design
MS-ETS1-1 Engineering Design

Length:
Approximately 60-90 minutes

Materials per team of 2-3:
-Sketching paper and pencil
-Cardboard sheet, roughly 12"x16"
-Straws
-Disposable plastic cups
-Popsicle sticks
-Saran wrap
-Tin foil
-Duct tape - 1“ wide
-Scissors
-Dissolving paper sailors made from water soluble paper, cut into gingerbread like form
-Storage bin, pitcher, water for testing, 8" deep
-Paper towels

Build a Submarine

Lesson Plan - Page 2

Challenge: Put on your engineering hard hats kids and help us build a submarine that is watertight! We need you to put your creativity and knowledge about how porous and permeable different materials are, and how tricky water is!
Goal - Keep our sailor dry and safe!

Procedure:
Open a discussion about building boats and lessons learned.

- Who knows what a submarine is?
- What can you tell me about them?
- What are they used for?
- Do you know how they work? How can they go up and down?
    - define buoyancy- ability to float in water or air
    - define ballast tanks - give stability by putting a heavy substance in
- How do ballast tanks allow the submarine to dive and resurface?
- What are some important safety features on a submarine?
- How important are the materials chosen in construction?
    - Permeability- a material's ability to let water pass
    - Porous- empty space in the material
- How deep can submarines go?
    - Over 800 ft! The Navy won't tell us the real number!

Show materials.

We have one goal, one design problem– when your submarine gets submerged into the water, water will try to fill it up as fast as it possibly can with force, pressure, and the fact that it's heavier than air. We need a plan for a boat that keeps the water out!

Demonstrate the dissolvable sailor by adding them to water!

Build a Submarine

Lesson Plan - page 3

1. Get into groups of 2-3.
2. Grab paper and pencil and start designing! Remember your goal.
3. Have a teacher review the design and ask “why’d you choose…” and “tell me about…”
4. Have the team approach the “store” for materials that match their design.
    a. Please consider bringing the materials over to the water and allowing them to interact with the water and the materials so they can see how that works. After, suggest they review their blueprint for changes. Functionality over design preferences.
5. Announce build time - approx. 30 minutes
6. Remind students not to forget to add the sailors to the inside!
7. Complete design and ask the teams to gather around the water bin.
8. Submerge submarines one at a time and observe for bubbles.
    a. If we see bubbles, what are they telling us?
9. Open them up to see if we have survivors!
10. Closing discussion:

- Did you enjoy being boat building engineers?
- Think about the submarines you saw today – what materials worked best?
- What didn’t work so well?
- Why questions to follow up what didn’t work so well.
- How would you change your boat for next time to improve?

Build a Submarine

Lesson Plan - Page 4

Middle school scale up -

Consider swapping materials or creating a new cost of materials list.

Suggested materials swap for a more challenging build:

- Removing Saran Wrap, adding paper bags
- Removing duct tape or narrowing the width, adding hot glue gun and masking tape
- Adding foam sheets
- Adding pipe cleaners
- Removing the plastic cups

Feel encouraged to use found objects and materials waiting to be reused into a learning exercise!

Notes

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