#SeaworthySTEM

Save the Sailors!

Build-A-Vessel Challenge

Grades 9-12

Teacher Guide

Seaworthy STEM™ in a Box Series

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Build-A-Vessel Challenge

Teacher Guide for 9-12

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Seaworthy STEM™ in a Box Educator Kit description:

Seaworthy STEM™ in a Box activities are a Navy initiative to provide enhanced Naval-relevant, standards aligned, hands-on activities to K-12 teachers and students. Components of this program include, curated sets of classroom activities that aim to build deep conceptual understanding in Naval-relevant content areas. The kits also includes comprehensive lesson plans, material lists, scientific background information, STEM related literacy books, and student activity sheets. The Seaworthy STEM™ in a Box program is designed to support teachers as they select content, acquire materials, and implement more hands-on STEM activities in their classrooms. Increasing student access to hands-on STEM activities, also increases awareness of STEM career paths, engage students in STEM, and support development of student's abilities in STEM content.

The Seaworthy STEM™ in a Box kits were designed to guide students through the scientific inquiry-based theory and the engineering design process. The content and Naval-relevant activities are aligned with the Next Generation Science Standards. The topics and content covered within the lessons are connected and scaffolded based on distinct grade bands (K-2nd, 3rd-5th, 6th-8th, and 9th-12th).

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Introduction

Welcome to an innovative curriculum designed to engage students in the world of engineering, problem-solving, and creative thinking. This curriculum is structured around three fundamental components, each carefully crafted to provide students with a comprehensive learning experience. In this curriculum, each lesson is divided into three parts: Journal Entry, Part 1, and Part 2.

Parts of Each Lesson

Journal Entry

The first part of every lesson serves as a bridge between what students already know and what they are about to learn. The Journal Entry is an opportunity for students to reflect on their prior knowledge and experiences related to the topic. These questions will stimulate critical thinking and prime students for the exploration of new concepts. The teacher can mold these questions into a format that best fits their class. This entries can be done in the student workbook, a separate journal notebook or another location determined by the educator.

Part 1: Introduction & Research

Following the Journal Entry, Part 1 of each lesson is dedicated to research and in-depth exploration. The students will delve into the subject matter, investigate key concepts, and gather valuable information. This phase is essential in providing the foundation for the Engineering Design Challenge, ensuring that students have the necessary background knowledge and skills to approach real-world problems effectively. Do not feel as though you have to strictly follow these instructions. Use the tools that are necessary for your students. This could include adding teaching strategies, word banks or other differentiation techniques to the lessons.

Part 2: Engineering Design Challenge

The culmination of each lesson is the Engineering Design Challenge. This is where students put their newfound knowledge and research skills to the test. They will work through the engineering design process, applying their problem-solving abilities to develop practical solutions. The challenges are crafted to mimic real-world scenarios, allowing students to experience the fulfillment of creatively designing their own products. Engineering education can be enriched by infusing elements of business-style competitions into your lessons. This approach not only deepens students' technical understanding but also hones their teamwork, critical thinking, and real-world problem-solving skills. This can be done by using the team dynamics page as a "business" team page. Remember, as the teacher you create your materials pricing list from what you have. This will allow you to have more control over the outcome of the lesson. The educator becomes the customer while the students incorporate regular pitch sessions as part of the final presentation. Play with the style of the lesson and build students up to feel the business dynamic that unfolds through the engineering process.

Here We Go!

By the end of this curriculum, students will have the tools and confidence to address real-world challenges in a systematic way. This curriculum is designed to provide the basics and help organize a young engineers thought patterns. Teaching students how to map out their thinking is essential in the development of world changing solutions. We are excited to embark on this educational journey with you! Let's get ready to journal, research, and create as we embark on a #SeaWorthySTEM learning adventure!

Table of Contents

Lesson Title:

Save the Sailors!

Build-A-Vessel Challenge

Time:

Average learning time is 4-5, 50 minute class periods

Student Objectives:

1. Understand the principles of buoyancy, stability, and materials in ship design.
2. Apply the engineering design process to construct a functional and efficient boat.
3. Test and evaluate their boat's performance on the water.
4. Collaborate with peers to solve real-world engineering challenges.

Lesson Overview:

In this high school engineering challenge, students will embark on an adventure to build their own #SeaWorthySTEM boats using a limited set of materials. They will apply their knowledge of buoyancy, stability, and materials to construct a boat that can carries "sailors" while remaining afloat.

Next Gen Science Standards (NGSS):

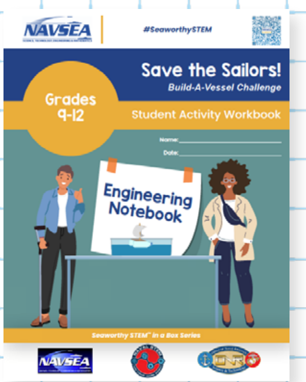
NGSS Standard: HS-PS2-1
Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on an object, its mass, and its acceleration.

NGSS Standard: HS-ETS1-3
Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Materials and Equipment List

- Cardboard or foam board
- Plastic containers or cups
- Craft sticks or straws
- Tape (duct tape, masking tape)
- Scissors
- Rulers
- Plastic wrap
- Small weights to represent sailors (e.g., pennies or washers)
- Water containers (to test the boats)
- Stopwatch or timer
- Teacher access to the internet (YouTube needs to be available)
- Student access to an internet compatible device
- Computer w/ attached projector
- Student Worksheets & Writing Utensil

**Teacher can include any other materials available*



Student Activity Sheets/Handouts:

Student Activity Worksheet:
Save the Sailors! Build a Vessel Challenge

Technology Tools:

Stopwatch or timer
Teacher access to the internet (YouTube needs to be available)
Student access to an internet compatible device
Computer w/ attached projector

Part I: Background Research

1 Pre-Assessment Activity:

The student journal response can be used as a pre-assessment for this unit. Have the students answer these questions in the "Journal Entry" section of their engineering notebook.

Sample Journal Prompts:

1. What is the most important part of a boat and why?
2. What do you know about structure and function?

2 Pre-Activity:

Have the students answer these questions in the "Think about..." section of their engineering notebook. The teacher can post the questions below for the class to reference when answering.

Tell the students to "Think of a Boat's Structure" then answer the following questions:

1. What are the parts of a boat?
2. Do you think the type of material used to construct a boat matters?
3. What are some examples of boats types that you know of?
4. Are all boats the same?
5. Sketch at least two boats that you have previous knowledge about

3 Hook:

Show this video about Naval Surface Warfare Center, Carderock Division's Maneuvering and Seakeeping (MASK) Basin: https://www.youtube.com/watch?v=DVLdg-MefdY

YouTube:

4 Background Research- Primary Sources:

Research Artifacts:

- Have students complete the:
  "**Let's Explore Primary Sources & Research**"

5 Background Research- Information:

Research Sheets:

- Have the students complete the:
  "**Type of Ships Research Sheets**"

6 Student Discussion:

After the students complete their research, use the information within both research sections to review with the students. Class discussions, share outs, partner shares or gallery walks are effective methods of communicating findings.

7 Engineering Design Challenge:

Discuss Ship Design and share Navy examples and explain the upcoming design engineering challenge. Some examples are included below:

1. **Aircraft carriers**: Large, powerful ships with a flight deck for the operation and landing of aircraft.
2. **Battleships**: Large, armored warships.
3. **Destroyers**: Fast and maneuverable warships designed to escort vessels and defend them against smaller threats such as submarines.
4. **Frigates**: Versatile warships that are smaller than destroyers and used for anti-submarine warfare, escort duties, and patrol missions.

Part 2: Engineering Design Challenge

Background Information:

A Navy boat is defined as a commissioned waterborne unit of the Fleet, not designated as a service craft, and capable of limited independent operation. It may be assigned to and carried on a ship as a ship's boat or assigned to a shore station or a fleet operating unit.

The term "hoisting weight" as used herein is defined as the weight of the boat completely fitted out and ready for service with machinery and electrical installation in operating condition. All outfit, navigational, lifesaving equipment and crew are on board. The fuel tanks are full, except in special bases as noted.

Check out the different types of boats here:
https://maritime.org/doc/boatcat/index.php

The Engineering Design Challenge:

The Navy has tasked your design team with creating a new sea vessel. Your vessel must be able to carry "sailors" without sinking. The goal of your design is to hold as many sailors as possible. Your team must be creative in determining what type of boat and features should be included for success.

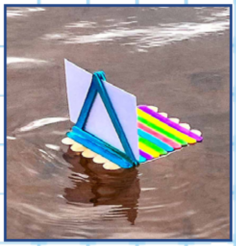
Procedure:

Pre-Activity: Students will fill out a Team Dynamics page to review expectations and goals of the challenge.

I What is the Problem?

- Have the students discuss the basic scientific principles associated with the lab: stability and buoyancy.
- Introduce the engineering challenge:
  - ***Design and build a boat that can carry as many pennies* as possible without sinking.***

Examples

Source: https://www.steampoweredfamily.com/how-to-build-a-boat-stem-challenge/

Source: https://hessunacademy.com/floating-mayflower/

Source: https://www.tes.com/teaching-resource/stem-boat-building-with-motor-and-propeller-11863119

Source: https://www.pinterest.com/pin/how-to-make-a-high-speed-hoxyfy-fxgppf-hostater-boat-using-dc-motor-youtube--511932682637013063/

****Pennies are an option but other materials can be substituted***

- Form small teams and distribute the materials. Note: If allowing students to choose materials at random, create a materials home-base (a large box or storage container) designated for hand-selected materials.
- Have the students formulate a problem (in question form) from the scenario provided.

2 What are the Criteria and Constraints?

- Have the students list out the criteria and constraints for the lab.
- Constraints: Provide your students with a list of constraints for the engineering design challenge.
- Discuss budget constraints (a limited number of materials per team).
- Have the students fill out the budget form for their design.

Possible ideas are listed below:

- You will have (pre-determined number) of class periods to design, build and test your project.
- Budget constraints

3 How can we Brainstorm and construct the Prototype?

- Have the student brainstorm multiple designs for their prototype.
- Students will choose one design, justify their choice in the writing section and build their models according to their designs.
- Emphasize teamwork, creativity, and adherence to budget.

4 How can we Test and Data Collection?

- Each team tests their prototype by:
  - A. Placing it in a container of water.
  - B. Add pennies one by one until the boat sinks.
  - C. Record the number of pennies the boat carries successfully.
  - D. Determine how you will collect data about your device.

Note teachers are encouraged to have students create their own step-wise procedures as well. Students may develop different models then the ones listed above, allow for experimentation and flexibility in data collection.

5 What are our Findings? Data Analysis and Reflection

- Team present their findings by creating a data chart, graph and reflection statement to discuss the findings of their prototype.
- Teams discuss what worked and what did not in their design.
- Reflect on the engineering design process by answering the following questions:
  - A. Does my prototype meet the requirements of the design challenge?
  - B. Can I improve the design from its original specifications?
  - C. How can I reduce the cost of my final prototype without sacrificing quality?

6 Let's Improve it! Class Discussion, Team Redesign Conclusion

- Discuss the most successful designs and strategies.
- Relate the activity to real-world applications in naval engineering and design.

7 Peer Evaluation of Teamwork

- Students will be providing feedback of teammates and collaboration.

Teacher Background Information / Notes:

Stability, buoyancy, and forces are fundamental concepts in physics and engineering. Stability refers to the ability of an object to return to its original position after being displaced, which is crucial in ensuring the balance and safety of various structures. Buoyancy, on the other hand, is the upward force exerted by a fluid that opposes the weight of an immersed object, allowing it to float. Understanding buoyancy is essential in designing ships, submarines, and other watercraft. Forces, including gravitational, buoyant, and drag forces, influence the motion and behavior of objects, determining how they interact with their surroundings and other objects. Together, these concepts form the basis for comprehending the behavior of objects in fluids and the principles behind various engineering designs.

Vocabulary Terms:

- Buoyancy
- Stability
- Displacement
- Engineering design process
- Hydrodynamics
- Newton's second law of motion
- Iteration
- Budget constraints

STEM Related Careers:

- **Naval Architect:** Designs ships, boats, and other marine structures.
- **Marine Engineer:** Develops and maintains mechanical systems on ships.
- **Oceanographer:** Studies the physical and biological aspects of the ocean.
- **Environmental Engineer:** Focuses on water quality and conservation.
- **Mechanical Engineer:** Works on various mechanical systems, including those in marine applications.

Notes

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The Seaworthy STEM™ in a Box curricula was developed through collaborative efforts of a team of individuals at the Naval Surface Warfare Center Carderock Division and Albert Einstein Distinguished Educator Fellows via an inter-agency agreement with the U.S. Department of Energy for the Albert Einstein Distinguished Educator Fellowship (AEF) Program. We are grateful to the following Content Specialists who contributed their knowledge and expertise by researching and writing on selected topics: Suzanne Otto, Stephanie Klixbull, Thomas Jenkins and Melissa Thompson. We'd also like to acknowledge the contributions of AEF participant Ms. Deborah Reynolds, the inaugural AEF Educator at Carderock that helped inspire the design of Seaworthy STEM™ in a Box content. Special thanks to Albert Einstein Fellow Melissa Thompson, for the creation of a collaborative high school engineering curriculum and supplemental additions to the early grade bands; career portfolios, workforce trading cards, and in-house short story publications. Gratitude to Carderock Outreach Specialist Ashlee Floyd, STEM Program Manager, Charlotte George, and Media Specialist Kristin Behrle for the creation and support of this naval endeavor that showcases the diversity of NAVSEA Sites.

It is the goal of the Seaworthy STEM™ Curriculum to embrace NAVSEA technologies from sites nationwide to empower the youth of our nation to purse STEM-centric career pathways. The views and opinions of the Content Specialists expressed herein do not necessarily state or reflect those of the AEF Program, the U.S. Department of Energy, or the U.S. Government. Reference herein to any specific commercial product, process, or service by trade name, trademark, service mark, manufacturer, or otherwise does not constitute or imply endorsement, recommendation, or favoring by the AEF Program, the U.S. Department of Energy, or the U.S. Government.

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