#SeaworthySTEM

Navigating the High Seas

A Sailor's Tool Design Adventure

Grades 9-12

Teacher Guide

Seaworthy STEM™ in a Box Series

Navigating the High Seas

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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).

Photo on the Cover: U.S. 5TH FLEET AREA OF RESPONSIBILITY – Operations Specialist 2nd Class Alex Moore monitors radars to identify aircraft in the Combat Information Center aboard the multipurpose amphibious assault ship USS Bataan (LHD 5). *Photo By: U.S. Navy Photo*

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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:

Navigating the High Seas

A Sailor's Tool Design Adventure

Time:

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

Student Objectives:

1. Analyze and interpret data related to measurement tool accuracy and precision.
2. Develop data visualization and analysis skills.
3. Apply scientific and engineering principles to solve real-world problems.
4. Understand the importance of data-driven decision-making in tool design.

Lesson Overview:

In this high school data analysis lesson, students will dive into the world of #SeaWorthySTEM engineering challenges. They will explore different historical documents and diagrams related to tool creation. This lesson will allow students to explore measurement tools from history and create their own tool for a unique purpose.

Next Gen Science Standards (NGSS):

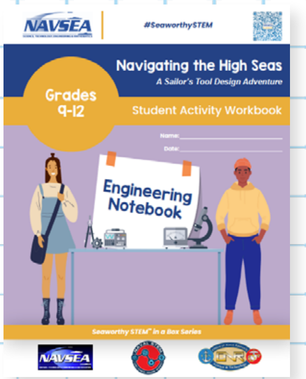
HS-ETS1-2
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

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.

Notes

Materials and Equipment List

- Assorted supplies (cardboard, paper, markers, scissors, glue, tape, etc.)
- Recycled materials (bottle caps, straws, plastic containers, etc.)
- Pencils, erasers, and rulers
- Graph paper or design software
- Research materials on precision measurement tools
- Computer or tablet for research and design software if available
- Access to a 3D printer or workshop for prototyping



Student Activity Sheets/Handouts:

Student Activity Worksheet:
Navigating the High Seas: A Sailor's Tool Design Adventure

Technology Tools:

Computer or tablet for research and design software if available

Internet access

Access to a 3D printer or workshop for prototyping

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. Why do you think we have a system for measuring things?
2. What would happen if we did not have a system to measure things?
3. What would happen if we did not have an organization that standardized measuring?

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 Tool they have used in life?" Then answer the following questions:

1. What are some types of tools that you know from home and what are they used for? Explain your thoughts.

2. Why is it important that a tool's structure matches it's function? Explain your thoughts.

3. What would happen if we did not have a standard for measurement? Explain your thoughts.

4. What would be the best way to classify tools? Explain your thoughts.

5. Why are measurements so important in science? Explain your thoughts.

YouTube:

3 Hook:

Show this video of the history of measurement: https://www.youtube.com/watch?v=7bUVjJWA6Vw

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: "**Measurement Tool 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 tools that professionals use to measure items; share Navy examples and explain the upcoming design engineering challenge. Some examples are included below:

1. **Radar Systems:** To detect and track objects.
2. **Sonar Technology:** For underwater detection and navigation.
3. **Global Positioning System (GPS):** Navigation, location, and positioning.

Part 2: Engineering Design Challenge

Background Information:

Measurement is a means of quantifying or qualifying data based on a known system of measurement. This means we are able to know specifications of an object by comparing it to already known values. Estimation is more than taking a guess! The ability to interpret measurement scales and approximate a quantity are essential Science, Technology, Engineering, and Mathematics (STEM) competencies. This important approximation tool helps interpret the world around us:

- Comparisons – relative size or quantity
- Magnitude of small and large numbers
- Ordering
- Spatial reasoning
- Sense-making
- Checking for reasonableness

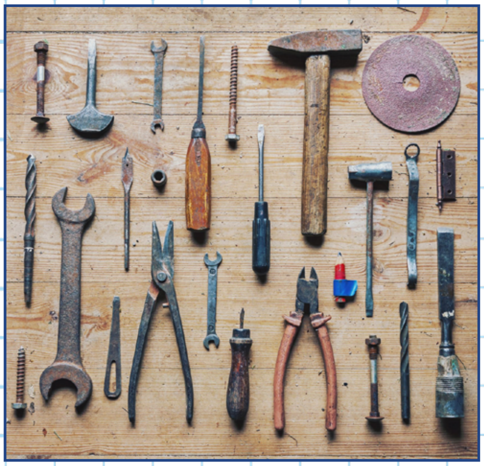
Estimation is used when it's not important to find an exact measurement. Estimations are also valuable when developing a hypothesis and evaluating if experimental data results are reasonable. Refining estimation skills through practice improves precision and accuracy! Taking measurements helps us understand how a system works and the how the compatible parts function as a whole. (Modified from https://www.nist.gov)

The Engineering Design Challenge:

The Navy has tasked your design team with creating or modifying a tool that can be used on a ship. Your tool must solve one of the defined problems presented by the teacher. The goal of your design is to consistently perform the same function with the tool. For example: measuring a dimension or performing a task. Your team must be creative in determining what type of tool and features should be included for success.

Examples

Source: https://www.britannica.com/technology/tool



Source: https://www.housebeautiful.com/home-remodeling/g28424890/best-tools-for-home/

Procedure:

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

What is the Problem?

- Have the students discuss the basic scientific principles associated with the lab: measurement, precision and accuracy.
- Introduce the engineering challenge:
    - ***Design and build a tool that focuses on one of the following:***
        - ***Follows an already known system of measurement, but the tool is a new design.***
        - ***Follows a new system of measurement, determined by student, with a standard of measurement defined.***
        - ***Performs a task such as tightening, moving or performing a function to help solve a problem.***
- 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.
    - The teacher can tell the student which of the problems to solve.
    - The materials used in the lab can be a constraint.
    - The teacher can also choose an item and the students need to create a tool to measure something about that item.

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.
- Team can either build or 3-D print their tool.

4 How can we Test and Data Collection?

- Each team tests their prototype by:

  A. Performing the task the tool was created for multiple times

  B. Recording one of the following: Accuracy, Precision, or a determined measurement the tool serves the purpose for.

  C. Record the data collected in the data chart provided.

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:

The history of tools dates back to early human civilizations, where simple tools were used for hunting, farming, and basic construction. As civilizations advanced, the development of metalworking led to the creation of more tools, such as axes, hammers, and chisels. This revolutionized tasks like building structures and crafting intricate objects. Technological innovations continue to expand the evolution of tools. With the inclusion of electricity and digital advancements, complex tasks can be accomplished with precision and accuracy. Organizations such as the National Institute of Standards and Technology (NIST) help maintain the standard for measurements around the world.

Vocabulary Terms:

- Ocean Currents
- Wind Patterns
- Data Analysis
- Ship Routes
- Nautical Charts
- Navigation
- Data Visualization
- Marine Engineering
- Oceanography
- Maritime Industry

STEM Related Careers:

- **Oceanographer:** Scientists who study the physical and biological aspects of the ocean, including currents, ecosystems, and climate.
- **Marine Engineer:** Engineers who design, construct, and maintain ships and other marine structures.
- **Data Analyst:** Professionals who collect, process, and analyze data to make informed decisions in various industries, including maritime navigation.
- **Cartographer:** Experts who create and interpret maps and charts, essential for navigation and marine planning.
- **Meteorologist:** Scientists who study weather and atmospheric conditions, providing critical information for maritime safety.

Notes

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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