Deep Dive Showdown

What design elements are essential to ensure that our submarine moves efficiently and remains stable while navigating underwater?

Deep Dive Showdown

Lesson Length

3-4 Class Periods (project can be broken up due to wait time needed to manufacture parts)

Overview

Curious about how submarines glide through the depts of the ocean? Let's dive into the fascinating world of underwater exploration! In this project, we will explore propulsion, buoyancy, and design using manufacturing equipment. Propulsion is the driving force that powers your submarine forward. Buoyancy is the key to controlling whether your submarine sinks or floats. Design is all about creating a submarine that can move smoothly underwater. With these principles, we will discover the secrets of submarine design and navigate the underwater world!

VDOE CTE/SOL Courses & Standards:

Science
Grade 6 Science
Physical Science
Life Science

CTE
Introduction to Technology and Engineering
Inventions and Innovations
Technological Systems

Math
Grade 6 Math
Grade 7 Math
Grade 8 Math

See page 9 for course standards

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Learning Objectives:

In this activity students will:

1. Design and build a submarine that is neutrally buoyant using manufacturing equipment.
2. Understand buoyancy, ballast, and propulsion and how it relates to the design and operation of submarines.
3. Experiment with fin and propeller design (and how they impact the submarine's movement through water).

Materials/Supplies:

*Materials can be modified as needed

- 3D printer; or
- CNC Machine; or
- Laser Engraver
- 2 liter soda bottle or plastic water bottle
- rubber bands
- plastic spoons
- popsicle sticks
- straws
- balloons
- paperclips
- waterproof tape or waterproof sealant
- razor blade or exacto knife *teacher discretion
- scissors
- needle nose pliers
- ruler
- tank for testing (make sure it is big enough for a submarine to travel a distance across)

Did you know a typical modern submarine may require as many as 2,000 drawings.

Key Vocabulary

- Buoyancy: the force that determines whether an object sinks or floats in water
- Propulsion: the act of driving or pushing an object forward, often referring to the method used to move a submarine
- Ballast: weight added to the submarine to help control its buoyancy and stability
- Stability: the ability of the submarine to maintain balance and not tip over while moving or stationary underwater
- Fins: flat or curved surfaces attached to the body of the submarine that help stabilize, steer and control its movement underwater
- Hull: the main body of the submarine that houses its components and protects it from water pressure
- Neutral Buoyancy: a state where a submarine neither sinks nor floats, allowing it to remain at a constant depth

Background Information & Resources

History of Submarines:
https://www.history.navy.mil/get-involved/for-educators/lesson-plans/elementary-school-lesson-plans/history-of-submarines.html

https://ussnautilus.org/education/

Virtual Tour Austrialian Submarine:
https://visit.museum.wa.gov.au/maritime/hmas-ovens-take-virtual-tour

Submarine Design:
https://www.marineinsight.com/naval-architecture/introduction-to-submarine-design/

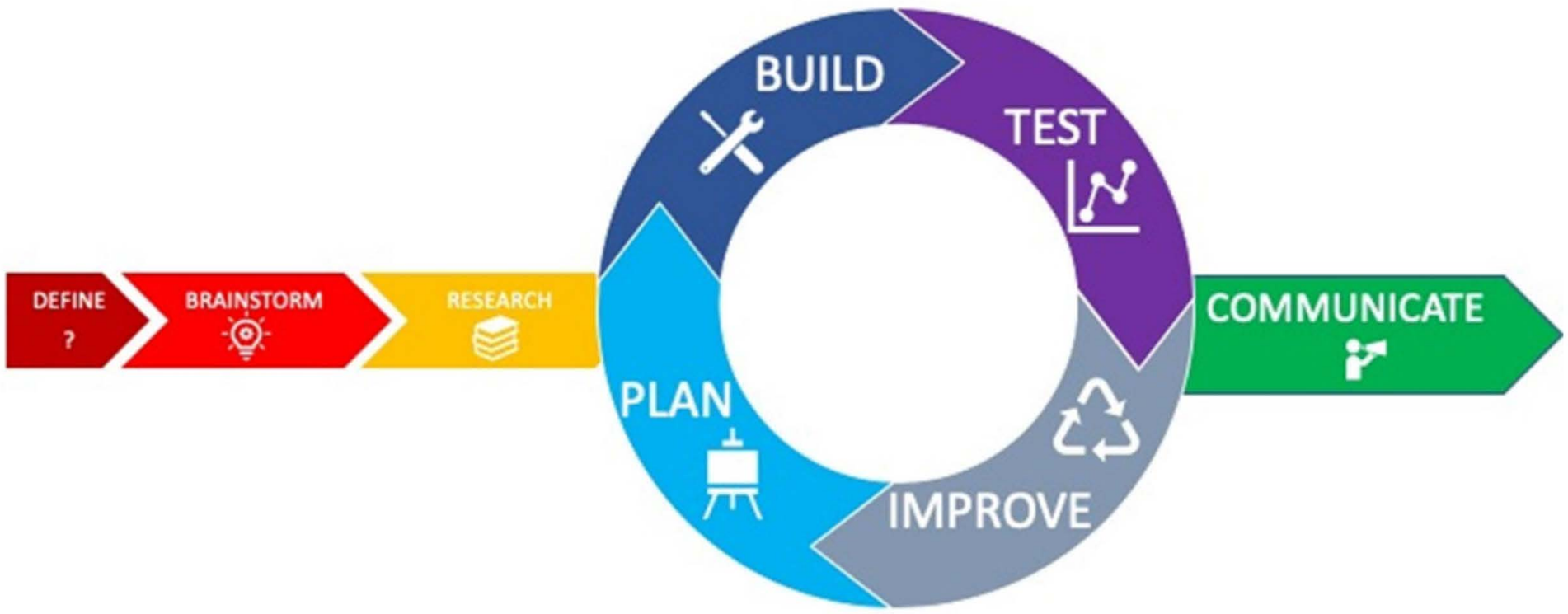
Deep Dive Showdown
Teacher Prep

Before beginning the activity, students/teachers can collect recyclable materials to use. Make sure that they have been cleaned out.

For the testing component of this project, the teacher will need to prepare a testing bin/pool/sink before and determine how students will test. This is determined based on classroom size, class size, and materials available. The teacher should have all materials prepped for submarine construction.

For this project, the use of manufacturing equipment is encouraged. This includes 3D printers, CNC Machines, and/or Laser Engravers. Teachers should prepare students with the software they need to use for these pieces of equipment. Teachers will also need to make sure they have supplies for these pieces of equipment on hand for this project.

Deep Dive Showdown Directions



- Define the problem and determine the parameters
- Brainstorm potential solutions
- Research the problem (this can be done before the brainstorm session)
- Plan: pick one solution, plan a prototype, and determine what data to collect to determine its effectiveness
- Build the prototype
- Test the prototype
- Improve the prototype and test it again
- Communicate the results

Challenge: Using manufacturing equipment (3D printer, CNC Machine, or Laser Engraver) design and build a small submarine that maintains neutral buoyancy and can move underwater.

1. Present the challenge to the students
2. Individually have students research submarine design, fin and propeller placement for submarines, and buoyancy. Discuss their findings.
    a. Things to talk about:
        i. Does location of the fin(s) matter on a submarine?
        ii. What does neutrally buoyant mean?
        iii. How are submarines propelled forward underwater?
3. In teams of 2-3, have students brainstorm ideas for their submarine.
    a. Brainstorming can look like sketches on paper, word clouds, or images pulled from their research. You decide how you want this to look.

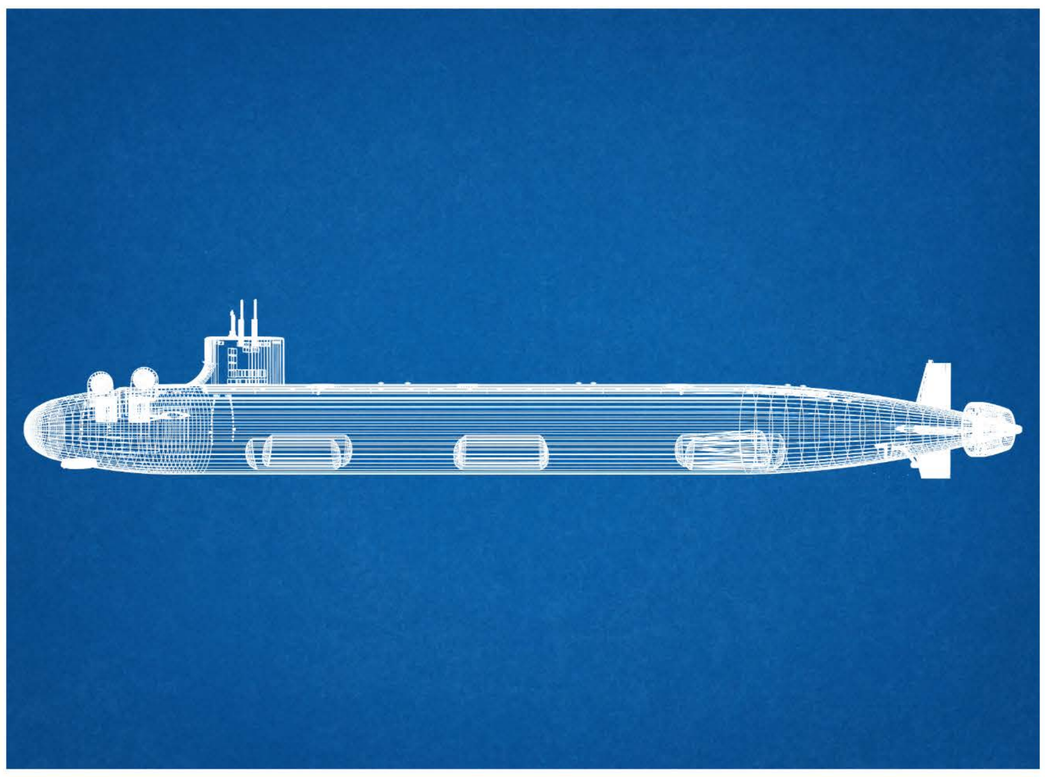
Deep Dive Showdown Directions

4. Have students decide on their design and plan how they are going to make their prototype.
    a. This includes deciding what piece or pieces of equipment they are going to use in their design (3D printer, CNC Machine, Laser Engraver)
    b. Students can have the option to make their entire sub using these pieces of equipment or a combination of consumable materials and manufactured parts.
    c. This would be a good time to work with students to help design and possibly test how something can be neutrally buoyant and also how the submarine will move across the water (rubber band powered is an example)
    d. Use this time to decide if the teacher needs to implement a size constraint due to the size of the testing tank. This will vary with each teacher.
5. Prototype Construction
6. Test each prototype
    a. Up to the teacher if there will be testing allowed throughout the construction process or if students have to wait until all prototypes have been completed
7. If time permits, students can redesign and retest their prototypes. If there is not time for that, students should complete a "report" that documents the positives and negatives of their prototype and how they would improve it.
    a. The report can look different depending on the teacher
8. Students should do a small informal presentation on what they learned, their design, and what they would do different. Teacher's can add additional talking points.

Parts that can be manufactured by the students on 3D printers, CNC machines, or Laser Engravers include the submarine hull, fins, and propeller.

Deep Dive Showdown
Take It Further!

- Have students explore different propulsion methods beyond rubber bands or balloons such as electric motors or solar power
- Explore sonar and sound waves, challenge students to think about how they would attach a system to their submarine
- Explore using the submarine for different tasks or underwater environments. How would the students designs change?
- Have students explore the environmental impacts of submarines or other underwater vehicles. Research noise, pollution, and disturbances to marine life.
- Collect data from the submarine testing and plot graphs to compare designs.



OLD DOMINION UNIVERSITY
Office of Enterprise Research and Innovation

VIRGINIA DIGITAL MARITIME CENTER

Deep Dive Showdown

VDOE CTE/SOL Courses & Standards:

Science

Grade 6 Science

- 6.1: The student will demonstrate an understanding of scientific and engineering practices by:
  - a) asking questions and defining problems
  - b) planning and carrying out investigations
  - c) interpreting, analyzing, and evaluating data
  - d) constructing and critiquing conclusions and explanations
  - e) developing and using models
  - f) obtaining, evaluating, and communicating information
- 6.6: The student will investigate and understand that water has unique physical properties and has a role in the natural and human-made environment

Life Science

- LS.1: The student will demonstrate an understanding of scientific and engineering practices by:
  - a) asking questions and defining problems
  - b) planning and carrying out investigations
  - c) interpreting, analyzing, and evaluating data
  - d) constructing and critiquing conclusions and explanations
  - e) developing and using models
  - f) obtaining, evaluating, and communicating information
- LS.9: The student will investigate and understand the relationships that exist between ecosystem dynamics and human activity

Physical Science

- PS.1: The student will demonstrate an understanding of scientific and engineering practices by:
  - a) asking questions and defining problems
  - b) planning and carrying out investigations
  - c) interpreting, analyzing, and evaluating data
  - d) constructing and critiquing conclusions and explanations
  - e) developing and using models
  - f) obtaining, evaluating, and communicating information
- PS.5: The student will investigate and understand energy is conserved

Math

Grade 6 Math

- 6.7: The student will
  - a) derive pi;
  - b) solve problems, including practical problems, involving circumference and area of a circle; and
  - c) solve problems, including practical problems, involving area and perimeter of triangles and rectangles

Grade 7 Math

- 7.4: The student will
  - a) describe and determine the volume and surface area of rectangular prisms and cylinders; and
  - b) solve problems, including practical problems, involving volume and surface area of rectangular prisms and cylinders

Grade 8 Math

- 8.6: The student will
  - a) solve problems, including practical problems, involving volume and surface area of cones and square-based pyramids; and
  - b) describe how changing one measured attribute of a rectangular prism affects the volume and surface area
- 8.8: The student will construct a three-dimensional model, given the top or bottom, side, and front views.

CTE

All Workplace Readiness Skills Competencies can be addressed throughout the project.

Introduction to Technology and Engineering

- Introducing Technology
  - Identify historical examples of technology
- Investigating the Effects of Technology
  - Analyze how an invention or innovation was influenced by its historical context and future need
- Examining Resources of Technology
  - Create sketches and drawings
- Designing Solutions
  - Describe the VDOE engineering design process
  - Demonstrate the use of an engineering design process
- Using the Engineering Design Process
  - Define the goal of a challenge
  - Design a device using criteria and constraints
  - Evaluate viable solutions
  - Select a solution
  - Plan the model or prototype
  - Produce a model or prototype
  - Assess the design
  - Describe how the solution could be improved
  - Communicate the results
  - Use the engineering design process as part of a team

Inventions and Innovations

- Exploring Tools for Invention and Innovation
  - Demonstrate safe use of a minumum of five tools and/or equipment
  - Demonstrate various types of measuring
  - Create sketches and drawings
- Explore Design and Creativity
  - Describe the VDOE engineering design process
- Applying the Engineering Design Process
  - Plan a solution to an engineering design problem
  - Build a model or prototype of the propose solution
  - Communicate the process and results of the proposed solution

Technological Systems

- Exploring Technological Systems
  - Analyze existing products or solutions
  - Describe the steps of the VDOE engineering design process
- Creating Systems
  - Plan a solution to an engineering design problem, as part of a team
  - Demonstrate the safe use of a minimum of seven tools and/or pieces of equipment
  - Construct a model or prototype of the proposed solution, as part of a team
  - Communicate the processes and results of the solution, as part of a team

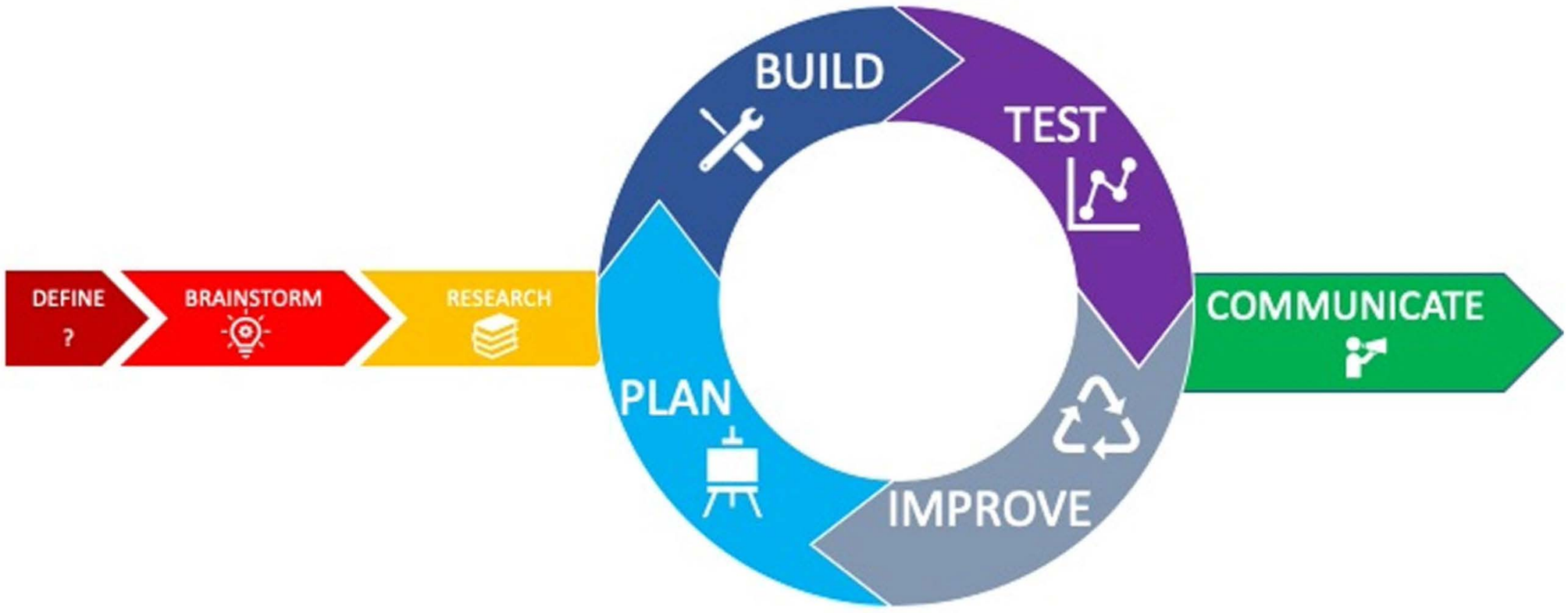
Project Management Plan

Team Member Roles

Team Goals & Timelines

Team Member Tasking

Research Planning



Sketches & Design Planning