How can we work on a boat?

<table>
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<th>Middle School</th>
<th>Standard(s): MS-PS-2; MS-ETS-1-1 through MS-ETS1-4;</th>
<th>Topic: How to work on a boat</th>
<th>Developed by: ASNE</th>
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<td>Overview:</td>
<td>Students will think outside the box on ways to work on a ship. They will discover how a dry dock works and see the dry dock area in FLEET.</td>
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<td>Image by U.S. Navy</td>
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Prior Student Knowledge Required:
- None

Student Learning Objective:
- A. Discover elements of the engineering process by engaging in a hands-on engineering activity.
- B. Discover the purpose of a dry dock and key elements.

Materials:
- “Boat” that groups of students can work with.
- A sink per group of students (a science lab, cafeteria, etc.) with drain stopper would be great.
  - If a sink is not available, a small container of water is acceptable.
  - See Step #4c to see why a sink is preferable.
- Computer with FLEET installed.
- (Optional, Step #11-14) Ability to project from the computer with FLEET so it is easy for all to see your screen.
- (Optional, Step #11-14) FLEET already has a sea-worthy boat created.
- (Optional, Step #14) Technology to play YouTube video

LESSON PLAN – (This uses the 5-E Model)

Engage
1. Group students as they come into the room, and present them with this question:
   a. You need to repair the hull of an aircraft carrier below the waterline. User your boat, the sink (or container), and your imaginations to design a way to work on the hull.

Explore
2. Initially problems the group will confront:
   a. What is a hull?
   b. What is an aircraft carrier?
   c. What is the waterline?
   d. Can they pick it up?
   e. Email us (fleet@navalengineering.org) if you encounter more initial questions.

3. Ways to address initial questions:
   a. You could ask them to figure it out on their own and students may turn to their phones and other nearby resources.
   b. You could instruct them to look up answers to their questions on their phones or on computers in the room.
   c. You could have answers already printed or written on the board. For example:
      i. Hull – the main body of the ship, including the bottom, sides and deck.
      ii. Aircraft carrier – A boat that is able to launch and land planes (search the USS Gerald Ford for images and descriptions).
      iii. Waterline – Where the surface of the water meets the side of the ship
      iv. If you want to pick it up, know that the air craft carrier weighs about 224,000,000 pounds and the average crane can lift 30 tons. (measurements are purposefully given in different units here, you may decide to use Scientific Notation or other units).
      v. If you decide to use cranes, know that the air craft carrier USS Gerald Ford is about 1106 feet long and 78 meters wide. (again, units are purposefully different)
4. Possible engineering solutions
   a. Using cranes to lift the boat. Although not cost effective or realistic, this is one solution. Groups that quickly reach this decision could be asked to find a more cost-effective solution. (Cost is a common design concern in life and in FLEET).
   b. Creating a device that lifts the boat out of the water. (This has been done historically. For example, floating dry docks used levers to lift ships.) Groups reaching this decision quickly could be asked to refine their design and consider whether the full weight of the aircraft carrier could be lifted using their design.
   c. Scuba equipment could be used for small jobs, but the group should consider how much tools and steel a scuba diver could handle.
   d. Pulling the drain in the sink is an ideal solution—these groups have discovered the dry dock. Groups that quickly reach this solution should consider weighs that the sink could be drained in real life.
      i. Most dry docks rely on pumps to actively remove the water. Like most sinks the dry docks are designed.
      ii. Tides could be used in some harbors to control the amount of water in the dry dock, but usually this is not sufficient to completely drain the dry dock.

5. If you have time, there are two more design considerations to address in groups:
   a. What else does the dry dock need to ensure the boat is not damaged?
      i. Possible answers that mimic real-life solutions:
         1. The bottom of the sink needs something to hold the ship. Dry docks use structures that center and support the ship.
         2. The water should re-enter the dry dock from the bottom (rather than from the faucet above). By slowly filling the dry dock with water, ships can be carefully returned to the sea.
   b. Use the real-life dimensions of the USS Gerald Ford to create a diagram that shows the necessary structures and machines to create a dry dock for an aircraft carrier.
   c. Many groups will struggle to get to this solution because it is out-of-the-box thinking. That’s ok today. You are working with engineering topics like this so that your students move away from textbook learning and toward real-world problem solving. You may even find that students that are not strong solving problems with one answer will excel dealing with problems that have multiple possible solutions.

Explain
6. Give a five-minute warning that you will share out soon. Ask the groups to create a written or visual description of their solution.

Elaborate
7. Groups will share their solutions one at a time.
8. Other groups should be encouraged to ask for elaborations if they do not understand aspects of the solution.
9. After every group presents, ask each group to describe two things that were key to the process they used to solve the problem. This will be your first foray into the process of engineering.
   a. If you are using an existing engineering process, begin to organize their comments into ways that will reflect your engineering process.
   b. If you are creating an engineering process for your group, write down this initial list of ideas on something that you can bring back later.
10. Tie the conversations together by emphasizing that engineering is a process that takes collaboration
and improvement to achieve the best solution given the constraints. Going forward you will continue to address problems that require creative thinking and have many possible solutions.

**Evaluate**

11. Gather the class around a screen that can show you interacting with FLEET. The first cut screen (shown below) shows the dry dock workspace.

12. Lead a discussion about the key features of the dry dock. Compare and contrast the images in this video to their designs.

13. (Optional: If you already have a ship in your dry dock that is seaworthy.) Show a couple elements of the game play so that students can participate next lesson. Specifically,

   a.  
      | Gives you access to parts of the ship you have not used yet. |
      | Gives you access to the parts on your current ship. |
      | A place to hold on to pieces that you are thinking about using soon. |
      | Use this button to change your view of the ship. (You can also right click and move around the interface. |

   b.  
      | Load your ship from the server (usually this happens automatically). |
      | Save your ship. Be sure to hit this button before closing out of FLEET. |

Created by American Society of Naval Engineers through a grant by the Office of Naval Research

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Completely delete your ship and start again. Some lessons will require you to do this. Students may want to keep a record of their ships and data so they can quickly recreate ships from previous lessons.

When you meet the mission requirements, hit this button to Practice or go on Missions.

14. (Optional, this could replace or supplement the previous step, Step #3) You could show this amazing time lapse video of a real dry dock being flooded and the ship returning to sea.
   c. https://www.youtube.com/watch?v=dw8kvPN0oK0

Closing

15. This is the first engineering design project. Use a closing moment to establish what type of design process you want students to use by reviewing the planning, design, evaluation, re-design, and help-seeking activities.

Additional Resources

A. Discovery has a five-minute video about the dry dock for Building Maersk’s largest container ship. The simulations are nice, the video discusses the concept of ballast, and the narrator describes the role of the pumps and supports very well: https://youtu.be/RUfGCngF9DI?t=5m1s

B. At times the U.S. has built floating dry docks that uses some of the same principles. There is a great description of dry docks with pictures at: http://www.msc.navy.mil/sealift/2005/August/drydock.htm

C. There is a national park on Anacapa Island, and its volcanic history is fascinating. Here are some links that further explain Anacapa Island and the other California Channel Islands. (The location of the dry dock is Anacapa Island.)
   b. Tourist information: http://www.visitcalifornia.com/attraction/anacapa-island
   c. Geology of California’s Channel Islands: https://www.nps.gov/chis/learn/nature/geologicformations.htm

D. ELA Connection: Scott O’Dell’s book Island of the Blue Dolphins was inspired by a woman stranded on the Channel Islands in the 1800s. The book is far removed from engineering, but ties into the historical development of the American west coast.