Boat Design Detailed Instructions

1. Start the activity by explaining that we are going to have a boat designing competition today, but first we must learn some things about how boats are designed.
2. Ask if anyone knows why boats float?
    a. Take a few probably wrong answers, then explain concept of displacement
        i. There's also an upward force (buoyancy) that's determined by the weight of the water displaced by the object. An object will float if the gravitational (downward) force is less than the buoyancy (upward) force. So, in other words, an object will float if it weighs less than the amount of water it displaces.
    b. Take two pieces of tin foil. Show how a piece of flat tin foil will float on the water surface in the cooler, but a piece of balled up tin foil sinks (because it displaces too little water for its weight)
    c. Fill the clear vase up to the very top with water and place inside the baking pan
        i. Drop the lemon into the vase
        ii. Show how the lemon floats
        iii. Take the empty cup and weigh it on the scale
        iv. Pour the water from the baking pan into the cup, and weigh that. Subtract the weight of the cup from the total weight of the water in the cup, to get the total weight of the displaced water
        v. Weigh the lemon. The lemon and the displaced water should weigh the same (or close to)
        vi. This is because, in order to float, and object must displace it's weight in water.
3. Show the different pictures of boats and talk about how different aspects of a boats design give the boat certain features:
    a. Length: the longer a boat is, the faster the boat can move through the water, but the harder it is to control the movements.
    b. Weight – the more a boat weighs, the more water it needs to displace to float.
    c. Width (beam): a wider boat provides more stability at the expense of speed. A canoe cuts through the water like a wedge, and a shorter boat needs a narrower beam to reduce the angle of the wedge cutting through the water.
    d. Depth: a higher-sided boat stays drier in rough water. The cost of high sides is extra weight and extra wind resistance.
    e. Stability and bottom shape: the hull can be optimized for initial stability (the boat feels steady when it sits flat on the water) or final stability (resistance to capsizing). A flat-bottomed hull has high initial stability, while a rounded or V-shaped hull has high final stability.
        i. Faster boats have V-bottoms, but they are difficult to turn and cannot go in shallow water. Flat-bottom boats are slower, but can go in shallower water, turn better, and have more stability.
    f. Keel: an external keel (beam across the bottom) makes a boat hold its course better, and can stiffen a floppy bottom, but it can get stuck on rocks and decrease stability in rough waters
    g. Profile, the shape of a boats sides. Sides which flare out above the waterline deflect water.

    h. Rocker: rocker is the amount of curve in the hull, much like the curve of a banana. A straight keeled boat, with no rocker, is meant for covering long distances in a straight line. The full length of the hull is in the water, so it tracks well and has good speed. As the rocker increases, so does the ease of turning, at the cost of staying on course.
    i. Hull symmetry: viewed from above, a symmetrical hull has its widest point at the center of the hull and both ends are identical. An asymmetrical hull typically has the widest section aft of center line, creating a longer bow and improving speed.
    j. Some boats, like submarines, use air pockets to control buoyancy: The ability to control buoyancy comes from the submarine's trim or ballast tanks which can be filled with either water or air, depending on whether the submarine needs to float or sink. When the submarine floats it means its trim tanks are filled with air.
4. Tell them they are now going to design their own boats using tin foil and straws. Straws can be used to create air pockets that help with buoyancy or add stiffness to a design. The goal of the boat is to hold as many pennies as possible.
    a. Hand out a piece of aluminum foil to everyone and put straws in the middle of the lobby floor
    b. If they need to cut things, they can come up and ask you, and you can cut for them (to avoid accidental scissor injuries)
    c. Explain that boat designs must be no longer than the straws (to keep the boats from being able to hold too many pennies)
    d. Give them 10-15 minutes to design a boat.
5. When it looks like boat designs are getting completed, start testing 4-5 boats at a time in the moat. Put the boats in, and add pennies 1-2 at a time until the boats sink.
6. If everyone has sunk their ships, hold a discussion about which boats floated the longest and why.
7. If there is time, let them try a second boat design.