

Boat Building



Age Range:
9+ years old

**National Science
Education
Standards:**

Unifying Concepts
and Processes:

K-12: Evidence,
models, and
explanation
K-12: Form and
function

Science and
Technology:

K-12: Abilities of
technological
design
K-12:
Understanding
about science and
technology

Physical Science:

K-4: Properties of
objects and
materials
5-8: Motions and
forces

Science as Inquiry:

K-12: Abilities
necessary to do
scientific inquiry
K-12:
Understandings
about scientific
inquiry

Approximate Time Required for Session:

1.5 hours

Purpose:

- To design a boat that achieves optimum results.
- To build a floatable craft that can withstand pressure applied to it.
- To understand what designs are suitable for boat construction.

Overview of Activities:

This session will require the campers to collaborate and problem solve to accomplish their objectives. They must work as a team to design a basic blueprint for a boat. After the team has designed their boat, they will use the materials and implements provided to build it. The boat must float in water and support weight that will be added to it in the test phase.

Background Information for Facilitator:

Boat building encompasses many different skill sets, from basic scientific and material knowledge to mechanical design. When building a boat, the hull is generally the most important consideration. The hull of the boat is the shell or framework which is the basis for its floatation. Hulls are designed to displace a volume of water that weighs more than the mass of the boat and its cargo. Before discussing the specific types of hulls, let's explore why this is such an important part of its design.

When an object is introduced into a body of liquid gravity pulls it down and displaces the liquid. For an object that sinks, the volume of the object is displaced. For an object that floats, the

Background Information Continued:

amount of fluid displaced is equal in weight to the displacing object. For example, if you immerse a sealed pint bottle into a tub of water you have just displaced, or crowded out, 16 ounces of water. Thus, a floating ship always displaces the amount of water equal to the mass of the ship.

As gravity pulls the displaced water down this causes an upward force on the object. This upward force is called buoyancy, and is equal to the weight of the water displaced by the object. Buoyancy depends on the volume of the liquid displaced and density of the liquid.

Boat designers have to consider buoyancy and friction when deciding on the shape of the boat's hull. Increasing the volume of the boat means more fluid is displaced and more buoyancy. However, increasing the volume of the object increases the surface area, which also increases the effect of friction as the boat moves through the water. If the objective is to carry heavy weight (e.g., cargo ship) the boat must be designed with greater displacement and power to overcome the effects of increased friction. If speed is the objective the boat should have enough displacement to stay afloat and a small surface area to minimize the effect of friction.

When designing your hull you must also consider stability. Stability is the property of the boat which causes it, when disturbed, to restore itself into an upright position.

The purpose of the boat and the type of waterways it will navigate play a key part in hull design and construction. For example, a "displacement hull" boat typically has a round bottom with a tear drop shape running bow to stern. Boats with this type of hull have larger interior spaces and are very efficient and easy to propel through water at low speeds. They travel through water at a rate determined by the length of the waterline (where the hull meets the water surface). Displacement hull boats are supported by buoyancy. These hulls are typically seen on deep water vessels,

Tips!

Mass is a measure of the quantity of matter present in an object.

Volume is a measure of how much space it occupies.

The density of the water influences the volume of water displaced.

As a boat moves through water there is friction. The water exerts a net drag force on the boat, slowing it down.

If the force of displaced water pushing on the hull is greater than the force of gravity pulling the boat down, then the boat floats.

Tip!

There are several variations of displacement and planing hulls. For example, flat bottom boats can easily ride on top of the water at high speeds.

They are intended for use on calm waters such as ponds, small lakes, and slow rivers because they are not very stable.

Background Information Continued:

such as cruise ships, fishing boats, and sail boats.

A “planing hull” boat has a “V” shape that allows the boat to rise higher out of the water as the speed increases much like that of a water ski. This provides greater stabilization and speed in rough water. A deeper-V improves the ability of the boat to cut across the water with less drag and greater efficiency. These boats are inefficient at low speeds because more power is required for it to push through the water and get on the plane.

Concepts and vocabulary:

Beam – the width at the widest part.

Bow – the forward (front) part.

Deck – the floor-like platform.

Draught (draft) – the depth of water a boat draws especially when weighted.

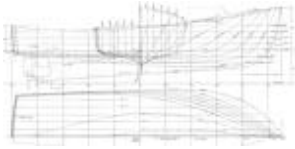
Keel – the center and bottom.

Mast – a pole rising from the deck to support a sail.

Port - the left side.

Starboard – the right side.

Stern – the rear (back) part.



Activity A: Boat Building

Approximate Time Required for Activity:

1.5 hours

Suggested Groupings:

Large groups of up to 20

Smaller groups of 3-5

Introduction:

In this activity, campers will use the materials provided to construct a boat. The boat needs to be designed to hold as much weight as possible before sinking.

Materials Needed:

- Pencils
- Writing tablets
- Sheets of aluminum foil, 12 inches x 12 inches
- Sheets of wax paper, 12 inches x 12 inches
- Straws
- Tape (water-proof preferred)
- Construction paper
- Scissors, how many for a small group
- Stream or water tub (at least 12 inches in diameter)
- Weights – either one cent pieces or metal washers (approximately 500).
- Easel for each large group
- Flip chart paper and markers for each large group

4-H SET Abilities:

- Predict
- Design
- Build/
Construct
- Test
- Evaluate

Tip!

For the water tub, a five gallon bucket will work.

Tips!

Remember to encourage lots of exploration. Avoid answering questions. Ask questions to help campers discover their own answers.

Preparation:

- 1) Make sure you have adequately prepared for the activity. Read the background information and activity. Practice making a boat in advance of the activity.
- 2) Determine the size and number of large and small groups. Have a plan for dividing the large group into smaller groups of 3 to 5 youth. Assign at least one trained facilitator to each large group and if possible each small group.
- 3) Obtain all materials and organize them so each group will receive equal amounts of supplies.
- 4) Locate a stream or fill the container with water for the weight test.
- 5) Consider making premade foil pieces for each group. Then all the groups will receive the same amount of building materials.

Introduction and Opening Questions (10 minutes):

- 1) Gather campers. Explain that they will be building a boat that can hold the most weight.
- 2) Divide campers into groups of about 20 people. Each group should have at least one trained facilitator.
- 3) Facilitate a discussion about boats and ships. Some discussion points include:
 - Explore the different types of boats the group is aware of or has seen.
 - Discuss the function or purpose of the various types of boats.
 - Evaluate the different building materials used in boats.
 - Compare the different shapes and sizes of boats.
 - Theorize what keeps a boat from sinking.
 - Discuss the different methods used to propel boats.

Experiencing I (10 minutes):

- 1) Brainstorm and discuss with the campers some ideas to consider in designing their boat before they start the building phase. Record ideas on flip chart paper.
- 2) Divide campers into small groups of 3 to 5.
- 3) Provide each small group with a tablet of paper and pencils and give them approximately 10 minutes to sketch the design of their boat.

Sharing, Processing, & Generalizing I (10 minutes):

Bring small groups together to form the larger group of 20.

- Ask each small group to share their experience in the design process.
 - Share the sketch(s) of the boat and explain how you came up with the design.
 - Explain how you worked as a team to design the boat.
 - Is there any additional information you would like to share?
- Do you want to change or adapt your design based on what you have seen or heard from the other groups? Explain the reasoning behind any changes you will make.

Experiencing II (45 minutes):

- 1) Break into the same small groups of 3 to 5.
- 2) Give each small group the construction material: Foil, wax paper, construction paper, scissors, tape, and 10 straws.
- 3) Allow the participants approximately 40 minutes to build their boat.
- 4) After all the groups have completed their boat, allow a few minutes for them to visually examine each other's creations.
- 5) Begin the process of weight testing by placing a boat, one at a time, in the water. Place one weight at a time in the boat. Count how many weights the boat can hold until it sinks. Record the results on the flip chart paper.

Tips!

Now that each that each group has designed a boat, they will construct a working model. They may realize that they will need to make corrections or adaptations to their original design. They may do so.

If you have more than one large group consider making as many water containers as the number of large groups you have or have each large group test the boat in a separate location in the stream. You will also need more weights (about 500 for each testing site). This will speed up the testing process.

Tips!

For the small group discussion, the facilitator should write the Sharing, Processing, and Generalizing II questions on flip chart paper unless each small group has a trained facilitator.

If materials were put in a tub or stream they would sink. This is because there is no water displacement to counteract the force of gravity.

Sharing, Processing, & Generalizing II (15 minutes):

Have the members return to their small groups and write down some of these topics.

- Review your boat's performance.
- Analyze your boat's strengths and weaknesses.
- If you were to build another boat designed to hold the most weight what improvements would you make.
- Develop tips for better organization or efficiency in your boat building.

Gather small groups to form the large group of 20 for the rest of the activity. Facilitate a discussion around these points:

- Ask them what they learned about boats from this activity.
- When building a boat designed to hold cargo (weight), what do you think are the most important aspects of the design to consider?
- Share some ideas on what conditions can affect the boats along with materials they could use to fix these problems.
- If we took all the materials, bundled them together, and put them in the tub or stream, what do you think would happen? Please explain.

Taking it One Step Further:

- 1) Do the activity again. Have groups redesign the boat trying to beat the number of pennies or weights the boat was able to hold last time. Test and compare results. Share.
- 2) Include propulsion systems such as sails, electric motors, etc. to the boat's design. The objective is to have the boat reach a destination in the shortest time. Have campers sketch, share, and build the boat. Test and record results. Compare results across boats. Discuss the most important features of the boat's design when speed is the objective. How did the design of the boat differ from the first activity? Explain the reasoning behind any differences noted.

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