The Boat and the Beetle

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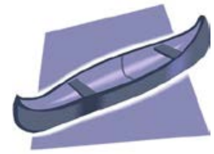

Lesson Overview

This lesson further develops principles of floating and sinking to young learners. It allows children to explore how boats and ships use the principle of displacement and buoyancy to stay afloat. The activities allow children to experiment with different shapes and design of boat 'hull' to see which floats best. It introduces the concepts of displacement and buoyancy in a practical activity. It also introduces the idea of a fair test. It can also be used to encourage children to use the engineering principles of and design, test, and improve.

Age Levels

4-7

Learning Objectives

- All children will experience making and improving model boats.
- All children will test whether their boat floats, and will have a chance to improve their design if it does not float successfully.
- All children will encounter and have the chance to practice using vocabulary associated with the topic e.g. float, sink, boat, hull.
- Most children will understand that the shape of the model boat hull affects whether it floats or sinks.
- Most children will be able to use their own words to describe the activity, and what they think is happening to allow floating or sinking.
- Some children will understand that displacement is when the shape of the hull (body of the boat) that they model can displace water (push it out of the way, so the space is filled with air) and this is why it floats (sits at the top of the water, breaking its surface tension). Some children will be able to report on this activity, using their own words to explain the principles involved correctly, (or with minor errors which after the teacher corrects they can eventually explain correctly.)

Anticipated Learner Outcomes

- I can make a model boat which will float on water.
- I can describe the body of the boat as a hull correctly.
- I can talk about the shape the hull of the boat needs to be to float on water.
- I can predict if a model will float or sink- and explain why it will do so using the idea of displacement.
- I can explain why my model works because of displacement and buoyancy.

Time Needed

Modelling Activity with discussion 10-15 mins, whole lesson with carousel 1hr.

Lesson Credit

- Dr. Rosie Ridgeway, Durham University

For Teachers:
Teacher Resources

◆ Key Vocabulary

- Float - to rest on top of a water (or a liquid)
- Sink - to go down below the surface of water
- Hull – the main part of a ship or boat: the deck, sides, and bottom of a ship or boat
- Displace - when a floating object physically pushes water out of the way
- Displacement - the volume or weight of water displaced by a floating body (as a ship) of equal weight
- Buoyancy – the ability of an object to float on water

◆ Common misconceptions

Surface tension- some children will be familiar with bugs which can ‘skate’ across the surface of water, using its surface tension- and will give this explanation for why a boat can float. They may have seen a paper clip ‘floating’ (actually it is balancing not floating) on the meniscus of water- again this is surface tension.

No object with holes in it can float- some children will opine that because the hull of their boats cannot remain floating with gaps in them then this will always be the case.

Light things float, heavy things sink - Adults: if you have allowed the children to play in water before (I hope so!!!) they will already be familiar with the principles of floating and sinking and will have some prior knowledge.
This means that they will have some ideas which they might over generalise, and you need to gently correct them.

Metal is too heavy to float- because we often allow children to experiment with materials in a small way, (before asking them to generalise their ideas, they may present misconceptions such as these). This is linked with the above misconception.

Surface tension is a really special scientific principle- well done for knowing about this, it is very interesting! However, in the case of this activity- we break the links between the water molecules with the hull of the boat- so the tension is lost, and the boat would sink suddenly- like the paper clip or bug would if the tension were broken by a drop of soap or a big wave.

◆ Correcting explanations

No object with holes in it can float- in the case of a boat, like you have made this is true. We saw today that this is because of displacement. In a boat with a hole in it the water isn't being moved out of the way, it leaks back in and fills up the hull and the boat sinks. (Adults-DO show them this with your own model boat- punch a reasonable hole in it so that it works quickly).
BUT, some objects do have holes in them but they still float- things like pumice stone, sponges, wood- this is because they have pockets of trapped air inside them, which is makes that object much lighter than the water, and so they still float at the top (because of buoyancy). Some things (e.g. a sponge) will fill those air pockets with water and will gradually sink, but others, like wood will not. This is why lots of people make rowboats and canoes out of wood- it is very buoyant.

Light things float, heavy things sink- This is a really good observation, because it is generally true- Adults ask the children to think of some examples where this is right- e.g. corks, rubber duck, toy boats vs. rocks, solid objects like a fork or key. BUT- because of buoyancy and displacement, we can make heavy things float if we design and shape them in the way you did today. Can children talk about a ferry boat or other large heavy object they have seen or experienced riding on? If not you may tell them a story from your own experience of a cruise ship or other boat ride.

Metal is too heavy to float- use the above explanation, you may want to supplement this with pictures of large metal ships at sea- such as tankers, aircraft carriers, etc.

◆ Materials and resources

- Student Worksheet
- Weighing scales
- Modelling clay/ plasticine
- inflatable play pool/ tank or large bowl of water
- Camera to photograph activity as evidence/ form part of assessment
- Key vocabulary display with explanations/ pictures
- Images to prompt/ support discussion

◆ Procedure

1. Planning- you will need to set up your classroom so that some children have access to the water and modelling clay (see 2) while others colour and illustrate their predictions/ and or outcomes of their experiment. You may also want to offer related play activities, such as toy boats and ships, paint a boat, or colouring sheets on the theme of water, transportations- e.g. colour in the sail on the boat etc. This will allow the adult to work closely with

small groups of children, and to carousel the children around different related activities.

2. For the activity: prepare your work space with tank of water, aprons, protect surfaces from spills.

   Prepare even lumps of the modelling material but leave several un prepared so you can explain the idea of making them the same so it is a ‘fair test’ to the children (you might want to link this to weight by using a pair of simple scales to measure the weight of each lump)- during the whole class introduction.
3. Small group experiment- Each child will need a piece of modelling clay for their model. (This activity should be done in small groups supervised by an adult who has read the material and has a good understanding of the principles involved.)
4. Individual children should have the opportunity to make a model ‘boat’ with their plasticine- they will need to test and retest, so will need access to the water. When the children are making the models the adults should repeatedly use the key words to repeat what the children are saying- for example- ‘I can see that you are flattening out the base of the boat- is that so it can displace the water?’ encourage the children to use the key concepts and vocabulary, or to explain these as they do the practical activity- this is not just play, it is a learning scenario designed to give them a concrete demonstration of a principle.
5. After each child has managed to build a model which floats, they should keep it for the extension activity in future lessons.
6. The adult should ask questions about the children’s models- throughout - why some designs worked well and others didn’t. In this way an assessment of children’s understanding can take place. You may want to take photographs of the children’s successful models. You may also want the children to draw their model, the activity and the outcomes- this may be using the prompt of the key words, or a prepared worksheet.
7. At the end of the session- when all children have had the chance to make and try out their models. Class discussion should follow to find out children’s understandings/ misconceptions around what is happening in the activity. Make reference to the key words and principles throughout, and ask children to illustrate the words or explain them in conclusion to the lesson (what they did, what this showed) and if any of the children have misconceptions at this point the adult should try to gently correct these (an able peer pupil may be able to help with this with support).

◆ Optional Literacy Connection

The following short story can be used as a starter to engage students in the hands-on activity.

Once upon a time there was a beetle who loved to tell everyone how fast he could run. “I am the fastest insect in the park”, he would say. His slow and steady friend the snail, tired of hearing him brag, challenged him to a race. “Ha,” the beetle thought to himself, “there is no way a snail could ever win against me.”

On the day of the race, all of the insects in the park gathered to watch. The centipede waved a checkered flag to start the race. The beetle zoomed past the starting line as fast as he could, while the snail carefully inched herself forward bit by bit. The beetle cried out “You will never win this race at that slow, slow pace.”

Out of breath from running, the beetle eventually reached a small pond of water. He thought, “I have plenty of time. I just will go <u>around</u> the pond.” The beetle sped off on his way.

Inch by inch the snail crawled along the path. As she reached the pond, she thought, “It would be much shorter if I could somehow float <u>across</u> the water.” Perhaps I could build a boat.

Can you design a boat to help snail get across the pond?

The snail gathered up some leaves, twigs and vine. She fashioned a small boat that helped her glide smoothly across the water of the pond. When she got to the other side, she hopped off the boat and could see all of her friends waiting for her at the finish line.

Little by little the snail crept along the path until she crossed the finish line at long last. All of her friends cheered. “Hooray for snail!” they cried.

A moment later the beetle came scattering across the finish line. “I can’t believe you beat me!” he said. “You know,” the snail replied with a smile, “being the fastest isn’t always everything”. “Sometimes if you just slow down for a moment and think, you can accomplish amazing things.”

◆ Optional Writing Activity

- Drawing a picture of what happened to your boat in its tank. (This can be used as a record, or assessment of child’s understanding of the activity).
- The child may write a sentence or word (dependent on age/ability) describing the activity alongside their picture: e.g. ‘sink’. Or ‘my boat floats’. Some children will require a dotted model to trace over the words: **My boat**

floats. If so, this part of the work should not be assessed (as handwriting is not part of the learning objective).

◆ Optional Extension Activity

Using prior activity as a prompt, in the next activity children continue the design, test and improve cycle to develop bigger and better boats.
This might be introduced as a boat challenge- where the boats they are modelling are cargo ships, or car ferries. Where children try to create the ship which can take the greatest load (of toy cars if the competition is about a car ferry, or pieces of dried pasta if it is a cargo ship) and float across the tank successfully. It is good to use solid objects (weighing about the same amount each) which can be counted onto each ship as it is loaded (to allow the children to see the 'fair' test principle in action).

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4 - 9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry
- ✦ Understanding about scientific inquiry

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design

◆Next Generation Science Standards – Grades 3-5 (Ages 8-11)

Engineering Design

Students who demonstrate understanding can:

- ✦ 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- ✦ 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- ✦ 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆Standards for Technological Literacy - All Ages

Design

- ✦ Standard 8: Students will develop an understanding of the attributes of design.

- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.