Floating and sinking

Introduction

Floating and sinking is a common activity in early years classrooms. Students' ideas about floating and sinking are intriguing. The strategies for developing their understandings discussed in this topic are examples of the probing, investigative and challenging activities that characterise effective science teaching and learning.

Key concepts of floating and sinking

The activities in this topic are designed to explore the following key concepts:

Early years

- Whether something floats depends on the material it is made of, not its weight.
- Objects float if they are light for their size and sink if they are heavy for their size.
- An object can be light for its size if it contains air, such as a hollow ball.
- Materials with a boat shape will float because they effectively contain air.
- Water pushes up on objects with an upthrust force.

Middle years

- Objects float if the upthrust force from the water can balance their weight (gravity force).
- Objects float depending on their density compared to water; for an object to float its density needs to be less than that of water.
- Objects float when air is enclosed in an object; their density is lowered, thereby increasing the likelihood of floating.
- The upthrust depends on the amount of water displaced.
- Objects float better in salt water (density of salt water is greater than that of pure water).
- Water surfaces have a cohesive force (surface tension) that makes them act like a 'skin'.
- Small, dense objects (e.g. a pin; a water spider) can 'float' on the surface of water without breaking it, due to surface tension effects.

Scientific terms associated with floating and sinking

- **force:** a push or a pull.
- **density:** amount of mass per unit mass of an object (i.e. the concentration of mass, or how 'heavy for its size' an object is). The density of water is 1 kg per litre.
- **pressure:** amount of force applied per unit area. At a given pressure, twice the area will experience twice the force.
- **Archimedes' principle**: A floating object will experience an upthrust force from water, equal to the weight of water displaced (pushed aside). It will sink into the water until it reaches the point where the weight of the water pushed aside equals its own weight. For an object that is floating, the mass of the material equals the mass of water that is displaced by the object (1 kg = 1 L of water). Dense objects cannot displace enough water to provide an upthrust force to counterbalance their weight, so they plummet below the surface. Objects made of material denser than water (e.g. a boat made of iron) can still float if they contain air so that the mean density is less than that of water.

Students' alternative conceptions of floating and sinking

Research into students' ideas about this topic has identified a number of non-scientific conceptions.

Students will have views about at least three aspects of floating and sinking that differ from science views. These alternative views centre around the questions:

- What do we mean by 'floating'?
- What determines whether something will float or sink?
- What causes things to float (i.e. what are the forces involved in floating)?

Interviews reveal that students can attach different meanings to the term 'floating' and that these meanings vary depending on the context (such as observing real objects in water as opposed to viewing line drawings). The students still seem to be at the formative level with respect to this idea and there are likely to be students in most classrooms whose understanding of 'floating' differs from scientists. Some students could become confused if teachers do not recognise this.

Students have a range of views about why some things float while others sink. Younger students (7–10 years) often do not realise that there could be a single explanation. Their response is to give explanations for individual materials. The explanations offered could be described as partial explanations. They focus on specific aspects such as lightness or heaviness and fail to take into account other aspects (such as size) needed to formulate a general rule that would explain all cases. Very few students seem to have an understanding of flotation that approximates that of scientists. Others realise that they do not really know why things float or sink, but they appear interested to know.

A number of students think that the length of floating material, or the depth of water underneath or on top of an object, affects flotation level. Some further believe that floating material will sink if the part above the water is cut off, or if it has vertical holes put through it. After initial experiences with reshaped non-floating material, almost all students realise that non-floating material can be shaped to float.

Activities

Practical uses for floating and sinking

Explore with the students what applications in technology are related to the topic of floating and sinking. Some examples are hydrometers, submarines, ships, airships, weather balloons, hot-air balloons, buoyancy vests and life jackets.

What is ‘floating’?

ACTIVITY: WHAT IS ‘FLOATING’?

Key idea: In scientific terms, things float if they are ‘supported by the water’ (or air) due to an upthrust displacement force. A fish can be said to be floating in water even if it is not on the surface.

Prior ideas: Consider the experiences children have had with floating and sinking prior to coming to primary school. What ideas would they already have about the topic?

You will need:

- **the figure *Objects in water*, or a set of similar objects or pictures.**

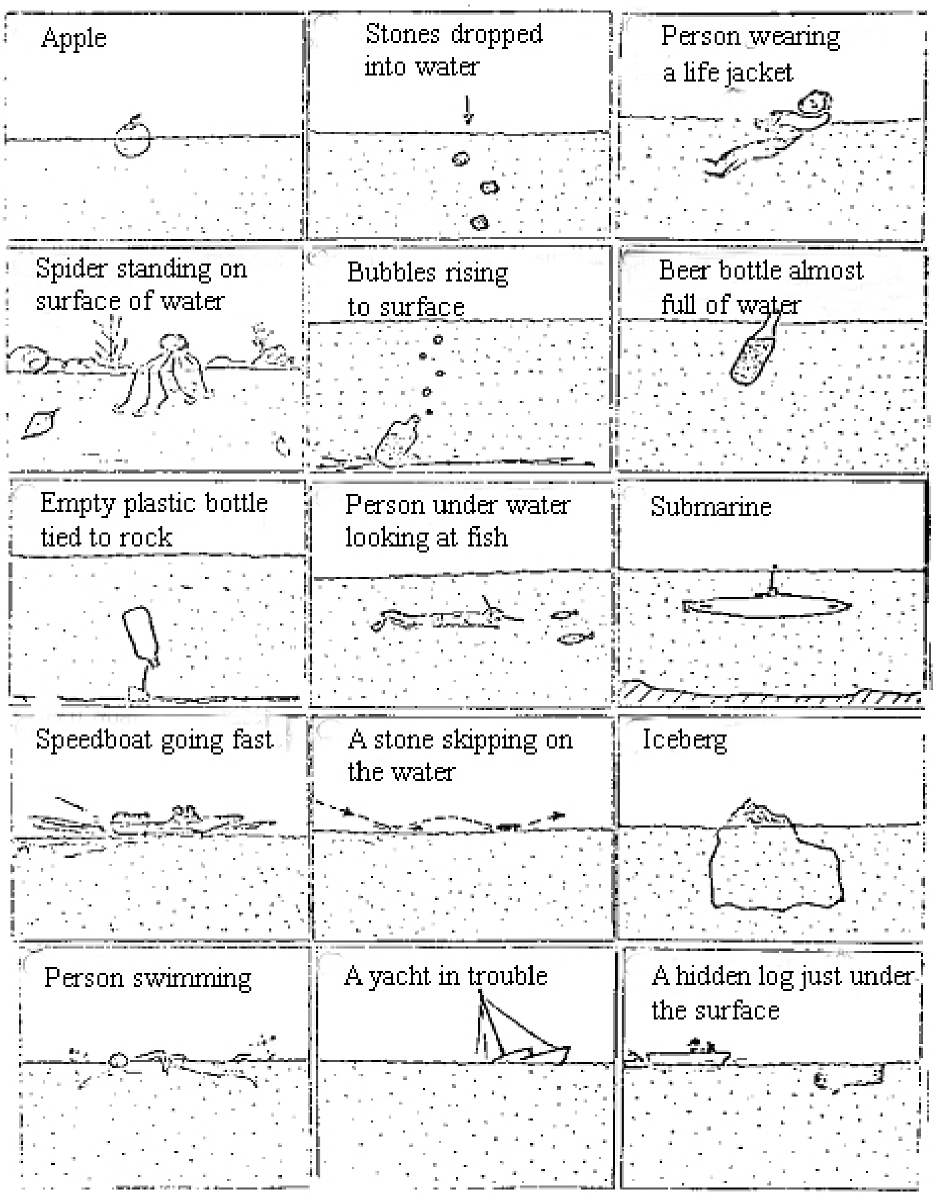
The term ‘floating’ is very loose. The everyday use of the term is different to the scientific use, which is developed around a theory of upthrust and gravity equilibrium.

Observe the objects illustrated in the figure *Objects in water*, devised by New Zealand researchers. Which objects would you consider to be ‘floating’? Can we arrive at a clear description of what we mean by ‘floating’?

Raise extra examples to do with objects in air: a helicopter, a hovercraft, a hot-air balloon or a helium balloon, a hovering hawk, a piece of paper blowing in the wind? What is keeping these up?

Explanatory note: The scientific understanding of ‘floating’ is that objects are suspended in water (or on water) or air, held up by buoyancy forces that balance gravity. Young children will sometimes express the idea that any part of an object above the water is floating, the rest is sinking, or that floating is a passive sort of state that does not include swimming or speeding. In everyday language the term ‘sinking’ can be used for a yacht that is currently floating but is crippled by a hole, for instance.

FIGURE: OBJECTS IN WATER



What determines whether something will float?

ACTIVITY: FLOATERS AND SINKERS

Teaching note: In this activity, some students will push for a small number of explanatory ideas (e.g. ‘these are heavy or have holes’, ‘these are made of light material’) and will acknowledge contradictions, while others (mainly children in the early years) will give a different reason for each object and not be bothered at all if their predictions are incorrect. Thus, we can gain insight into the level at which a child is constructing an explanation and considering evidence, separate from their conceptions.

When establishing a class discussion on this, you could collect on the board a list of ideas based on evidence as a shared class text. For example, ‘The aluminium floated for a while, then sank. We thought it was because it had air inside it to make it lighter’.

Another strategy is to challenge students’ simple idea that ‘heavy things sink’ by asking them to find heavy things that float, such as a candle (or light things that sink, such as a paperclip). This will involve talking through what we mean by ‘weight’ as opposed to density.

Key ideas: Objects float or sink depending on the material they are made of—whether they are heavy or light ‘for their size’. Air trapped inside objects reduces their effective density. This is also the case with boat-shaped objects.

You will need:

- **a tub or bucket of water**
- **various objects of different size and shape that will float or sink (cork stopper, eraser, metal paperclip, candle, plasticine, tennis ball, plastic lid, bolt, aluminium foil, etc.)**

Give groups of students ten or so objects and ask them to predict which will float in water, which will sink quickly or slowly, and which will float somewhere between.

It would be useful to design a worksheet that will enable you to record predictions and subsequent observations of the objects in water, with comments. Challenge students to consider the implications if their predictions turn out to be incorrect. Use questions such as:

- **Why do you think this floated and that did not?**
- **This did not float as you predicted. Can we work out why that is? Do you have a different view now?**
- **This crushed aluminium foil is floating. Do you think you could find a way to make it sink?**
- **Do you think these floaters have anything in common?**

After testing each of the objects, students should write down a reason why some objects float and others sink. Is there one reason or many?

ACTIVITY: FLOATING/ SINKING STORIES

Read *Who sank the boat?* (Pamela Allen 1982, Nelson, Melbourne) and/or *Mr Archimedes’ bath* (Pamela Allen 1980, Collins, Sydney), and discuss the relevant concepts raised in the books. Focus on what happens to boats as they take on more weight, and on the way water is displaced. Notice that the displacement of water is determined by the immersed volume of objects rather than their surface area.

Archimedes and boats

ACTIVITY: FLOATING PLASTICINE

Key idea: Dense materials can float if made into a boat shape.

You will need:

- **a lump of plasticine (for younger children aluminium foil can be more easily fashioned into a boat shape)**
- **a tub of water**
- **marbles to use as weights.**

Give students a ball of plasticine and ask them ‘will it float?’ Students can test this after guessing. Ask the students ‘could it ever float?’ When might the plasticine float? Students should be encouraged to make the plasticine float by itself by modifying the shape until it does.

Having done this, the students could discuss the shapes they used. Which shapes float the best? Which shape will carry the most passengers (marbles) without sinking?

ACTIVITY: ARCHIMEDES CAN

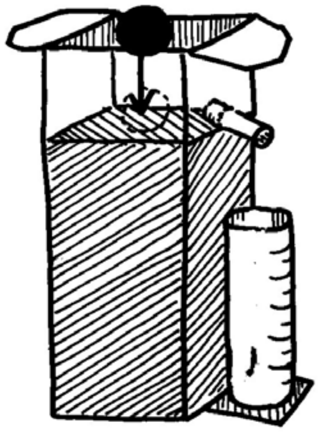
Teaching note: This activity is appropriate for the middle years or secondary school. With the activities that focus on the relative density of water, a similar approach could be taken. The words ‘dense’, ‘thick’, and ‘heavy’ will probably be used interchangeably by students unless special care is taken, but they can readily appreciate that adding salt to water helps support the egg, and can relate to stories or photographs of swimming in the Dead Sea, which has an extremely high salt content.

Key ideas: An object will push aside an amount of water equal to its volume. The upthrust from water is related to the amount of water displaced.

You will need:

- **an empty milk carton**
- **a drinking straw**
- **scissors**
- **water**
- **sticky tape of Blu-Tack**
- **a small measuring cylinder or jar with level markings**
- **plasticine.**

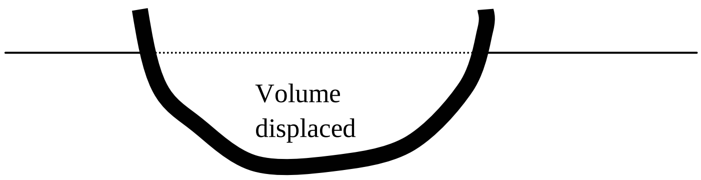
An Archimedes can measures the amount of water pushed aside by objects when they float or sink. Stick a short straw into the top of an empty milk carton to make a spout, and seal it with tape or Blu-Tack. Fill it with water to the point where no more water runs out of the spout. Place a narrow jar or measuring cylinder underneath the spout to catch the water.



Take a lump of plasticine the size of a ping-pong ball and drop it carefully into the can. Measure the amount of water that overflows. This is the volume of the plasticine.

Set up the can again, removing the water from the jar, and squeeze the plasticine into a flat shape. Predict what will happen if you drop the plasticine into the can. Try it. Is there more or less water?

Now shape the plasticine into a boat that will float in the can. Set the can up once again and predict how much water will be pushed aside by the floating boat. Will there be less, the same, or more water? Try it. Can you explain your result?



Explanatory note: The *Archimedes can* activity invariably astonishes those who try it. The plasticine has the same volume whether it is round or flat, so the first two results should be the same. The same amount of water is pushed aside by the same amount of plasticine. The boat, however, pushes aside much more water. The reason is that the air enclosed by the boat is also displacing water, and so more water is pushed out. This extra water pushed aside means that the upthrust force is much greater on the plasticine (Archimedes' principle), and it will float. It is air enclosed within the boat shape, therefore, that causes the boat to float.

Upthrust forces from water

ACTIVITY: UNDERWATER NETBALL?

Key idea: The upthrust increases as more water is pushed aside.

You will need:

- **a netball**
- **a garbage can full of water (this activity can also work with a medium-sized plastic ball in a bucket of water, but the effect is not as impressive).**

Attempt to push a netball under water contained in a garbage bin.

You will be able to feel, quite tangibly, the upthrust force which depends on the amount of water being pushed aside (displaced). Draw a diagram representing the forces at work here.

What if the ball was full of a dense material like steel, rather than air. Imagine it almost submerged. How would the upthrust from the water compare with that for the netball in the same situation? Why would the netball pop up, and the steel ball sink, in this situation?

ACTIVITY: BRICKS SUPPORTED BY WATER?

Key idea: Water exerts an upthrust force that opposes the force of gravity and effectively lessens the weight of objects.

You will need:

- **one or two bricks**
- **a long cord to tie to the brick/s**
- **a garbage can full of water.**

Lower one or two bricks, suspended by a long cord, into the water. Predict what you will feel before trying it.

Write a statement that captures what the last two activities tell us about why things float.

Explanatory note: As the bricks enter the water, the weight felt in the rope becomes much less because now the upthrust from the water is helping support the bricks.

ACTIVITY: MEASURING UPTHRUST

Key idea: Water exerts an upthrust force that opposes the force of gravity and effectively lessens the weight of objects.

You will need:

- **an elastic band**
- **plasticine**
- **a bucket full of water.**

Attach a lump of plasticine to an elastic band. The stretch of the elastic band is a measure of the weight. If the plasticine were heavier the band would stretch more.

Predict what will happen to the stretch of the band when you lower the plasticine into water. Try it. Now explain in terms of a diagram of the forces. Explain it in words.

You might like to try this with a spring balance. What could you measure?

ACTIVITY: CARTESIAN DIVER

Key idea: Water pressure can affect weight and therefore upthrust.

You will need:

- **a water dropper (glass is best, or weight the plastic dropper slightly with plasticine)**
- **a plastic juice bottle with a wide neck and a screw top.**

Partly fill a small glass or plastic dropper with water so that it just floats. Put it in the top of a plastic bottle full of water and screw the lid on. The dropper will sink if the container (with the top on) is squeezed.

Can you work out what is happening when you squeeze the bottle?

Look carefully at the dropper as you squeeze. You may notice the water level changing.

Vary the conditions: the amount of water in the bottle, the amount in the dropper, try weighting the dropper, loosen the lid, etcetera. What makes a difference, and why?

Explanatory note: Squeezing the bottle increases the pressure and drives more water into the dropper as the air is compressed. The added weight increases the density to the point where the dropper sinks.

Floating in different liquids

Teaching note: These activities are appropriate for middle years and up.

Key idea: The following activities are linked to the idea of relative density. Objects that do not normally float can be made to float in water made dense with sugar or salt. A liquid will float on top of another liquid that has greater density.

ACTIVITY: COKE FLOAT

Place cans of 'diet' coke and 'classic' coke in water. Prediction? Observation? Explanation?

ACTIVITY: EGGS–CEPTIONAL!

You will need:

- **a fresh egg**
- **salt**
- **bowls of water.**

Place a fresh egg in fresh water, then in salt water. Notice what happens. Put a fresh egg in a bowl of water, then add salt to the water. The egg will float. Now, with care, start over again and arrange for fresh water to sit on top of the salt water. The egg will float—but where?

ACTIVITY: POTATO FISH FLOATER

You will need:

- **salt**
- **a container half full of water**
- **another container of fresh water**
- **coloured dye**
- **a potato**
- **cellophane.**

Mix a cup of salt into a container half full of water to make brine. Once this is done, carefully fill the container with water containing coloured dye. This should sit on top of the brine.

Make a fish out of a slice of potato, using some coloured cellophane for fins. Place the fish in a container of fresh water. It should sink. What do you predict will happen if you put your fish in the container with dyed water and brine? Try it and see.

Explanatory note: With the *Potato fish* activity, it is important to establish that the potato will sink in fresh water, and to have students make the brine solution quite concentrated. In both this and the *Liquid sandwich* activity, students must pour carefully so as not to mix the solutions.

ACTIVITY: TESTING THE DENSITY OF LIQUIDS

You will need:

- **a drinking straw**
- **plasticine**
- **oil**
- **methylated spirits**
- **salt water**
- **tap water.**

Compare how high an object floats in oil, methylated spirits, salt water and tap water.

Make a hydrometer using a straw and plasticine. Attach the plasticine to the end of the straw so that it partially sinks but remains upright. Put numbered marks along the straw to measure the depth to which it sinks in each different liquid.

The scale can be arbitrary. Make up a table showing the relative depth for each liquid—if you use 'one' as the depth marking for water, the depth measure for each other liquid is a measure of that liquid's relative density in informal units.

Explanatory note: An object will float higher in brine (salt water) since it needs to displace less of the denser liquid to counterbalance its weight.

Floating liquids!

Key ideas: Liquids line up with a less dense liquid floating on top of a denser liquid. Hot water is less dense than cold water. Brine is denser than normal water. Alcohol and oil are both less dense than water.

ACTIVITY: LIQUID SANDWICH

You will need:

- **glycerine**
- **brine (salt water) or sugar syrup**
- **tap water**
- **alcohol (e.g. methylated spirits)**
- **oil.**

Glycerine, brine (salt water) or sugar syrup, water, alcohol (e.g. methylated spirits) and oil will float one above the other in that order, if they are poured carefully, one at a time, into a tall glass. This happens because of the different relative densities. The effect is dramatic if each is coloured with a different food dye. Cream will float on milk for the same reason.

Drop into these layers some small objects made of plastic, wood, a piece of potato, etcetera. You will find they will sink through some of the liquids and float at the line (interface) between liquids, depending on their density.

ACTIVITY: SWAPPING LIQUIDS

You will need:

- **two identical glasses**
- **hot and cold water**
- **red wine**
- **cooking oil**
- **salt.**

Fill one glass with normal water with food colouring in it. Fill the other with hot water.

Put a card on top of the glass with coloured cold water. Turn it upside down, and place it on top of the other glass. Now slide the card so that a small gap is opened between the two liquids. What would you expect to happen with the hot and cold water?

Explain what you see.

You can explore the same effect with:

- **salt water (brine) on top and fresh water below**
- **water above and red wine below**
- **water above and oil below.**