PRIMARY + STEM

Teaching Resource

ACTIVITY: Ships

ACTIVITY OVERVIEW

It is not foremost on people's thoughts but many of the items we use in our daily lives are shipped into Australia from some other part of the world. Everything from cars to soft toys, refrigerators and TVs, lunchboxes and shoes, mobile phones and brooms, to imported foods from faraway lands… In fact, according to the United Nations' International Maritime Organisation, ships transport 80-90 per cent of everything that the world needs or wants. Without engineering feats in the form of superstructures like container ships – we wouldn't be enjoying these modern-day conveniences so readily and affordably.

The focus of this activity is on the 'generate' and 'produce' components of the design process. Students build boats that can support the weight of a can of food in the 'Yes I Can Challenge', and they explore how forces like weight and buoyancy can be manipulated by changing the shape and size of an object. This learning is also extended into the real world, where they see how real ship-builders put these superstructures together.

SYNOPSIS

It is not foremost on people's thoughts but many of the items we use in our daily lives are shipped into Australia from some other part of the world. Everything from cars to soft toys, refrigerators and TVs, lunchboxes and shoes, mobile phones and brooms, to imported foods from faraway lands… In fact, according to the United Nations' International Maritime Organisation, ships transport 80-90 per cent of everything that the world needs or wants. Without engineering feats in the form of superstructures like container ships – we wouldn't be enjoying these modern-day conveniences so readily and affordably.

The focus of this activity is on the 'generate' and 'produce' components of the design process. Students build boats that can support the weight of a can of food in the 'Yes I Can Challenge', and they explore how forces like weight and buoyancy can be manipulated by changing the shape and size of an object. This learning is also extended into the real world, where they see how real ship-builders put these superstructures together.

Foundation – Year 2

- The way objects move depends on a variety of factors including their size and shape. For example, a push or a pull affects how an object moves or changes shape (VCSSU048)
- Explore the characteristics and properties of materials and components that are used to create designed solutions (VCDSTC017)
- Use materials, components, tools, equipment and techniques to produce designed solutions safely (VCDSCD020)

Year 3 – 4

- Forces can be exerted by one object on another through direct contact or from a distance (VCSSU064)
- Explore the characteristics and properties of materials and components that are used to create designed solutions (VCDSTC017)
- Investigate how forces and the properties of materials affect the behaviour of a designed solution (VCDSTC024)
- Investigate the suitability of materials, systems, components, tools and equipment for a range of purposes (VCDSTC027)
- Select and use materials, components, tools and equipment using safe work practices to produce designed solutions (VCDSCD030)
- Evaluate design ideas, processes and solutions based on criteria for success developed with guidance and including care for the environment and communities (VCDSCD031)

Year 5 - 6

- Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (VCDSCD038)
- Apply safe procedures when using a variety of materials, components, tools, equipment and techniques to produce designed solutions (VCDSCD040)

ACTIVITY, MATERIALS AND INSTRUCTIONS

Activity

Students put their engineering skills to the test as they build boats to participate in the 'Yes I Can Challenge'!

The challenge is to build boats that can support the weight of ONE unopened can of food.

For older students, the challenge could be modified to building boats that can support the greatest number of cans, or carry the heaviest load.

Materials

Demonstration

- Clear container (e.g. jug or plastic bowl)
- Water
- A floating object (e.g. ping-pong ball)
- A sinking object (e.g. golf ball)
- A dishwashing sponge cut into cubes, similar in size to the balls
- Enough Blu-tack or plasticine to make a ball similar in size to a golf ball

Per class of 30 students:

- Recycled containers of various materials (e.g wooden, paper, plastic, metal)
- Recycled packing material (e.g. bubble wrap, etc.)
- Adhesives (e.g. masking tape, packing tape)
- Cans of food (e.g. 95g tuna, 400g beans, etc.)
- Small inflatable pool filled with water, or large plastic tub
- Optional: Timing device (e.g. stopwatch)

Theory

The teacher conducts discussions and demonstrations that will help students build better boats, focusing on:

i) properties of materials to choose

ii) forces at work

Materials

1. Discuss the suitability of different materials to make the hull (main body) of the boats with.

What are some favourable properties for constructing boats?

It ought to be rigid, strong, waterproof, light, flexible, etc.

What are some qualities that are not helpful for building boats?

It should not be very absorbent, brittle, elastic, soft, etc.

2. Demonstration: Density

a) Fill the container to the brim with water

b) Show students a ping-pong ball and a golf ball

Ask students to make a hypothesis (prediction): which one will sink/float? What are some reasons for their hypothesis?

Place balls gently on the surface of the water. The golf ball sinks and the ping-pong ball floats.

c) Show students the dishwashing sponge.

Place it on the water surface when it is dry. It floats when it is full of air (less dense). Then hold it in the water and squeeze to fill all the holes with water. The sponge sinks now because it is more dense than water.

This shows us that objects that are very packed (denser than water) sink and those that are full of air (less dense than water) will float. Can students think of other materials that float (e.g. Styrofoam), or sink (e.g. glass marbles, iron nails etc.)?

Key learning: Material that is less dense is more likely to float.

Forces

When designing a boat, it is important to consider the forces acting on the system so that it is stable and supports the weight of a can of food.

1. What do students know about forces (pulls and pushes) which determine how objects move?
   Forces act on objects and have direction, size, and they work in opposites. In the boat, gravity will pull on the boat downwards. We call this weight. The opposite force is buoyancy, which pushes the boat upwards.

2. Use the 'Forces' diagram (Discussion Section) to show the different outcomes when these two forces interact.

3. Demonstration: Shapes and Forces
   Show how different shapes can alter the forces working on the object.

a) Show students a Blu-tack ball.

What do they think will happen if the ball were gently dropped into a container of water? The Blu-tack ball sinks like the golf ball.

From their experience, what do they think will happen to the Blu-tack ball if its shape changes?

b) Shape the Blu-tack ball into a boat and gently place it on the surface so that it floats. (Some practice will be required prior to this demonstration.)

The 'boat' floats.

This tells us that it is the shape of a boat, and not the material it is made of, that determines whether it floats. Consider ships made from metal that float and iron nails that sink in water.

Key learning: The shape of an object can determine whether something floats.

4. The weight of the boat increases when the can is loaded on the boat.

Can students find a way to increase the buoyancy? Challenge students to test this idea first with different-sized containers, to discover the relationship between the size of the boat and how much load it can carry.

The bigger the boat, the greater the buoyancy force it can produce when more load is added onto it.

Activity

'Yes I Can Challenge'!

The objective of the activity is for students to design and build boats that can successfully support the weight of one can of food.

Students could also vote for winners in several categories (e.g, the most stable, the most interesting, the most innovative, etc.).

For older students, the challenge could be modified to the boat that can hold the greatest number of cans without sinking.

Investigate:

Students explore the materials that are supplied to make their boats with.

What can they use? What tools will they need?

Generate:

Students use what they have learnt from the demonstrations and what they know of floating objects to generate ideas and discuss options, based on the materials that are available.

What materials should they use? What shapes can they make or use from the recycled objects to make their boats? How can they make it stable when food cans are loaded so that it doesn't tip over? How do they secure the different parts well so that it doesn't fall apart? What other parts would students need to make the boat more stable?

Produce:

Students collaborate to build their design.

Are they able to work well together and take turns so that the boat gets built?

Evaluate:

After the challenge, students evaluate the design of their own boat using criteria that has been set (i.e. the number of cans their boat could support, and also how they thought they had worked as a team).

Did they take turns to do things? Listen well to one another? Did they have fun together? They could also write down three things about their boat or process that they had liked, and three ideas for improvements to their boat.

If students enjoyed the activity, how about watching how engineers put together a real-world cruise ship in the following time-lapse video? The process and coordination are simply astounding!

https://youtu.be/lavm7CausyA 0:00 – 5:00

HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

Foundation - Year 2

In both Science and Design and Technologies, students explore the properties of materials and how they are used. Can students identify some advantages and disadvantages of making the hull (body of the boat) from different materials (e.g. wood, steel, plastic, cloth)? And if a material is not suitable (e.g. sponges) because it is too absorbent and will sink when it has soaked up water, what can be done to it so that it can be used to build a boat?

Another way to use this activity is to design a boat for the class to sail around the world in, discuss the different types of functions students would like on the boat (e.g. a climbing wall, a slide), and suggest materials for the building of this dream boat/ship. Someone dreamed this a long time ago, and it resulted in cruise ships like these:

Best Cruise Ships: Discover Our Top Rated Ships | Royal Caribbean Cruises

Years 3/4

This lesson is a good extension activity for the teaching of forces at this level. This activity focuses on the two forces – weight and buoyancy – and clearly illustrates the directions in which they work, while appreciating how they work in opposite directions. The activity allows students room for creativity when they manipulate the magnitude (size) of these forces to make their boats float.

Can students manipulate the buoyancy force in this activity so that the boat can carry double the number of cans of their original design?

When the cans are added, the weight is increased, so buoyancy also has to increase to ensure the boat remains floating. The secret is about increasing the size of the vessel to increase the upward force (buoyancy) and also improving the stability so that the 'boat' doesn't topple over.

Years 5/6

Large ships, such as container ships and cruise ships, are some of the largest contributors to greenhouse gas emissions because most of them rely on heavy diesel fuel. Do students have any ideas of how ships can be designed to use energy more sustainably? Students could add a technology (e.g. solar panels, a device to convert wave energy to electrical energy, etc.), to their boats in the 'Yes I Can Challenge'.

In science, students learn about how energy transforms from one type into another, and how other forms of energy can be transformed into electrical energy. The 'boat' in this challenge doesn't have the ability to move. Can students design a way to make their boat move a distance without touching it directly? (e.g. How about putting a sail on their boat, and creating wind - either by fanning furiously, or bringing an electric fan towards it?)

DISCUSSION SECTION AND KEY THEMES

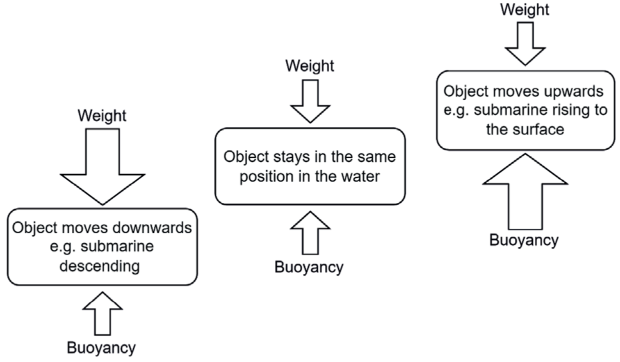
KEY THEMES

There are several considerations when building a boat in this activity: forces, density, and buoyancy.

Forces

Whether the boat floats or sinks in water comes down to the forces acting on it. Forces have magnitude (strength), they have direction, and they often work in opposites.

The forces involved in sinking and floating are weight and buoyancy. Weight is a force that works in a downwards direction, pulling the vessel down. The weight increases when more cans of food are loaded. The opposite force to weight in this activity is buoyancy – it pushes the vessel upwards.



Vessels (e.g. submarines and ships), and animals (e.g. fish and octopus, and even scuba divers) manipulate these two forces in order to move up and down, or stay stationary in water.

Density

Density is the measure of how much 'stuff'(matter) is in an object, compared to how much space it takes up.

It is calculated with the following relationship:

Density (in g/cm3) = mass / volume

Note: The density of water is 1g/cm^3

Engineers must consider the density of building materials when designing boats, submarines, underwater pipelines and cables.

Anything that is less dense than water will float in water, and anything more dense than water will sink.

But this doesn't mean that boats must only be made of materials that are less dense than water (e.g. logs and plastic). Compared to vessels from the past, ships and boats are now made of steel, instead of wood because steel is stronger, more durable material and easier to shape. Yet steel is a lot denser than water. If thrown into the sea, a steel ball will sink to the seabed. To make it float, engineers shape the steel, so that it forms a shell enclosing large air spaces. The combined density of heavy steel and air inside will be less than the density of water and allow the boat to float.

When adding more cans to the boats in this activity, students should make sure that their vessels are large enough (have greater volume).

The concept of buoyancy is associated with the legend of Archimedes, the famed Greek mathematician and engineer who had a 'Eureka!' moment when he was having a bath over 2000 years ago.

He realised that the more he submerged his body, the more water was displaced (ran over the bath). He discovered the Archimedes' Principle, where the buoyancy force is the same as the weight of the water that has been displaced.

Buoyancy force can be calculated with the understanding of Archimedes' Principle. The buoyancy of the boat can be found using this relationship:

Buoyancy (in Newtons)
= Density of water x volume of displaced water x gravitational pull

Simply put, since something bigger can displace more water, a bigger ship has greater ability to increase it buoyancy force. This explains how even something as heavy as a fully loaded shipping container, a luxury cruise ship, or even an aircraft carrier, is able to float and move in the oceans.

For the boat to remain floating in this activity, the upward buoyancy force must be equal to the weight pulling it down. When a can of food is loaded onto the boat, the downward directing weight increases. To float, vessels must be big enough so that they have the capacity to produce the upward directing buoyancy force that is necessary.

QUESTIONS AND ANSWERS

What is the difference between a boat and a ship?

The main difference is their size – boats are smaller than ships. A ship is technically a vessel that is at least 500 tonnes or above. Another difference is where they sail - ships sail in oceans and high seas but boats tend to operate in smaller bodies of water and along coasts. Since ships are so big, they tend to have a captain and a crew, whereas boats can be manned by one person.

What is the biggest ship ever built? Is it bigger than the blue whale?

The largest living thing in the world, the blue whale, can grow to 30m long and about 150,000kg in mass. In comparison, the biggest ship by weight is the Prelude, owned by the Shell petroleum company, is 480m long and weighs more than 4000 of these massive creatures! This ship is also a facility and is not open to the public. She is currently in Western Australia where she will call home for the next 20 years or so!

The largest ship students can sail on currently is the cruise ship known as the 'Wonder of the Seas'. It is more than 360m long and weighs the same as about 1500 blue whales – still very impressive figures, especially when there are swimming pools, cinemas, rock climbing walls onboard!

World's largest ship, Shell's floating LNG vessel Prelude, heading to WA | PerthNow

What is a yacht? I don't even know how to say it!

This tricky word is as tricky to spell as it is to pronounce.

Here are two ways to pronounce it: How to pronounce YACHT in English (cambridge.org)

Yachts are large sailboats, which are powered by sails, using the force of the wind. They do not require any form of fossil fuel to propel. In the time before the discovery of motors or engines, it was the only way to travel across large distances.

Sailboats can be small (dinghies) or large (yachts). There are many names for the different types of sailboats – they vary by the type of hull (main body of boat), keel (provides stability), and sails. Common sailboat types include catamarans, trimarans, sloops, cutters, and schooners.

The annual Sydney to Hobart Yacht Race takes place every Boxing Day and is one of the most difficult yacht races in the world.

How do submarines sink and surface?

Submarines can control their buoyancy, allowing them to sink and surface. There is a large ballast tank, which controls the depth of the vessel by adjusting the quantity of water it lets in or out.

When submarines want to surface, water is forced out of the tanks. This makes the submarine's overall density lower than the surrounding water and the submarine ascends. When submarines want to descend, water is let into the ballast. This makes the overall density greater than the surrounding water and the submarine sinks.

How do ships sink?

Ships sink for several reasons – and most of them involve the hull, or main body, of a ship being flooded by water. Once this happens, the weight of the ship becomes larger than the buoyancy force keeping it afloat, and it becomes denser than the surrounding water. The vessel continually sinks until it is completely submerged. This is why we see ship crew in movies desperately bailing water out of ships. Ships generally get flooded during bad weather, when there is a loss of stability, or when part of the hull gets ruptured during a collision.

The unforgettable sinking of the RMS Titanic occurred because the ship struck an iceberg, which tore open several small holes in the hull, letting water in. The Titanic remains resting in the seabed of the North Atlantic Ocean.

Are ships and boats still made of wood?

Ancient Viking, Chinese, Spanish, Portuguese, and English all built boats from wood like oak, pine, and teak because wood is less dense than water and can be shaped to form large ships for battle and trading. Wood is still used to make small boats today but not for larger vessels because it undergoes problems like wood rot, cracking, shrinking, and swelling.

This makes them expensive to maintain.

Since steel began to be mass-produced in the 1800s, it replaced wood as the material of choice. It is more durable (longer lasting) and stronger, and less likely to deform. Other materials like fiberglass and aluminium are also popular options especially for smaller vessels because they are lighter and easier to shape.

Boat Types – Boating Valley

If there are electric cars, are there electric ships?

Technologies for hybrid diesel-electric engines and for fully electric engines already exist for smaller vessels but most big ships like cruise ships, container ships and tankers still use heavy diesel oil.

It has been estimated that one of these large ships produce as much CO_2 as 70,000 cars, as much nitrogen oxide like 2 million cars, and as much fine dust as 2.5 million cars. With the current estimate of 90,000 ships in the waters, these figures become mind-boggling! The International Maritime Organisation (UN) estimates that by 2050, ships will contribute to 20% of global CO_2 emissions if nothing changes.

For there to be more electric ships in the future, more work needs to be done to develop powerful batteries that store electricity without being too heavy. Electric Ships: the Future of Shipping - Infineon Technologies

Can boats be made out of recycled plastic?

Many boats are already made with a type of plastic called fibreglass, also known as glass-reinforced plastic. It is a common material used to build the hull of boats because it is lighter, stiffer, more durable, and doesn't rot or rust. It's very exciting that some organisations and companies have successfully replaced fibreglass with recycled plastic like polyethylene. In 2016, a boat made from 30,000 recycled thongs sailed 500km from Kenya to Tanzania to raise awareness of plastic pollution in the seas. In May 2022, a Dutch company started selling 3D printed boats from recycled plastics that can be recycled themselves to make new boats.

Boat made of recycled plastic and flip-flops inspires fight for cleaner seas along African coast | | UN News

Rotterdam company 3D prints boats from recycled plastic | NL Times

Who is the youngest person to sail around the world?

The honour currently goes to Laura Dekker who holds both Dutch and New Zealand citizenship. She achieved this feat in 2012. She was 16 years and 123 days old when she had circumnavigated the globe in 518 days in her sailboat called Guppy. A year earlier, in 2010, 16-year old Australian Jessica Watson(OAM) had sailed unassisted and non-stop around the world in 210 days in Ella's Pink Lady.

List of youth solo sailing circumnavigations - Wikipedia

If I'm stranded on an island or a coast in Australia, should I build a raft to get help?

If being stranded on an island or near a body of water without any help is even a remote possibility, then learning how the Aboriginals built rafts might be a good idea. To venture along waterways and fish, the Bardi, Worora, and Djawi people from the Kimberley region in Western Australia built 'kalwas', while the Kaialilt and Lardil peoples living in the Gulf of Carpentaria in Queensland made 'walbas'. Very light materials were used to build these rafts so that they could support the weight of a paddler.

Rafts - Australian National Maritime Museum (sea.museum)

SUPPLEMENTARY READING

Archimedes

- Fact or Fiction?: Archimedes Coined the Term "Eureka!" in the Bath - Scientific American

Floating and sinking

- Upthrust, floating and sinking - Higher - Pressure in fluids - Edexcel - GCSE Physics (Single Science) Revision - Edexcel - BBC Bitesize
- Why do Ships Float? | Let's Talk Science (letstalkscience.ca)

Pirates

- Blackbeard's Ship Confirmed off North Carolina (nationalgeographic.com)
- Ching Shih: From pirate queen of the South China Sea to aristocrat and businesswoman - YP | South China Morning Post (scmp.com)

TOPIC WORDS

- Vessel
- Boat
- Ship
- Yacht
- Submarine
- Float
- Sink
- Density
- Buoyancy
- Volume
- Materials
- Forces
- Sail
- Stability

PRIMARY + STEM

For more teaching resources, visit

WWW.PRIMARYANDSTEM.ONLINE

Supported by

The Invergowrie Foundation

Swinburne University

The INVERGOWRIE Foundation

SWINBURNE SWINBURNE UNIVERSITY OF TECHNOLOGY