Chapter K: Moving Bridges

AIMS & OBJECTIVES

- to recognise the three main types of moving bridge
- to explore how bridges move and how this affects things around them
- to consider how a client's needs may alter the type of bridge designed for a particular location

It isn't always the users of the bridge that move: in special cases, the bridge moves too!

CONTEXT

Moving bridges are usually used over water to allow fast following traffic to keep moving on top of the bridge, while occasionally stopping traffic to allow tall boats to pass underneath.

There are three main types of moving bridge:

- Bascule Bridge – moves up and down vertically in an arc
- Swing Bridge – moves from side to side
- Lifting Bridge – lifts completely up above the water

The different styles of bridge are used depending on the span they need to cross, the size of the boats to pass under and the landscape on either side of the water.

LANGUAGE OF BRIDGES:

Aesthetics: This is about how something looks. If a bridge is primarily designed to be aesthetically pleasing, the engineers are more concerned with how it looks. It may be the public and the architects who view the appearance of the bridge as of equal importance to how it works.

Bascule Bridge: Bascule is a French word meaning to tip over or seesaw. Bascule bridges move up and down vertically in an arc shape.

Client: This the generic name for the people or organisation who have asked for a job to be done. In this session, it is the organisation who has asked for some moving bridge solutions.

Functionality: This is about how something works. If a bridge is primarily designed to be functional, the engineers are more concerned with how it works.

Elevation: In a technical drawing, this is the view from the side. This view is used on engineering plans to show how a bridge design will look from the side, almost as if you're standing in a boat on the water, looking at the bridge over the span of the river.

Lifting Bridge: This moves the bridge up, above the river like a lift. They tend to have towers on either side that the bridge moves between on its way up and down.

Maintenance requirements / to maintain: This is a list of things that are needed to keep the bridge looked after once it has been built, so it is still safe and lasts a long time.

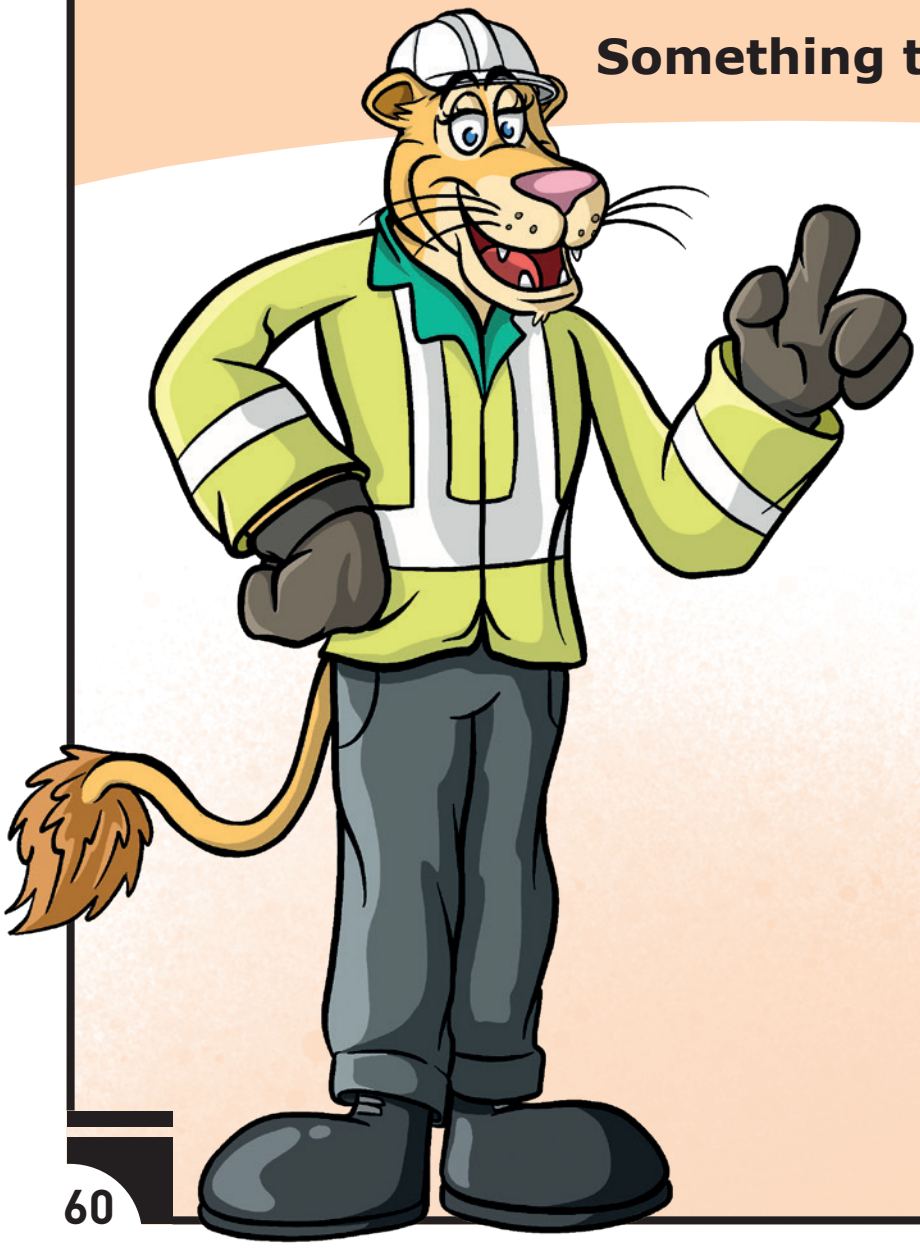
Plan view: In a technical drawing, this is the view from above or a bird's-eye view. This view is used in maps and on engineering plans for a new bridge design, showing how the bridge and landscape look from above.

Swing Bridge: This moves horizontally from side to side or around a central pivot to open and close the bridge.

You will need...

- Drawbridge demonstration, per group:
  - Empty cereal box
  - Scissors
  - Hole punch
  - String
- Lift bridge demonstration, per group:
  - 2 empty cereal boxes
  - Hole punch
  - Scissors
  - String
  - Thin piece of card, roughly the same size as the cereal boxes (A4 was used here)
  - 2 straws (wider milkshake type straws are ideal but not essential)
- Handout: *Moving bridges*
- Moving bridges challenge, per group:
  - Handout: *Moving bridges challenge*
  - Craft card e.g. 150-250gsm
  - Scissors
  - Split pins

Something to Try:



Moving bridges are usually used over water to allow fast following traffic to keep moving on top of the bridge, while occasionally stopping traffic to allow tall boats to pass underneath. In situations where land space is limited, or the river is relatively narrow, other bridge designs would not work: a beam bridge is too low to allow ships to pass under, an arch bridge can only get tall enough for tall vessels to pass under when the river (or bridge) is very wide, and other options (such as suspension bridges) require long approaches on either side.

There are three main types of moving bridge:

BASCULE BRIDGE:

Bascule bridges move up and down vertically in an arc shape. This is similar to how a drawbridge works. Learners can explore the way a drawbridge works using this simple demonstration.

CEREAL BOX DRAWBRIDGE:

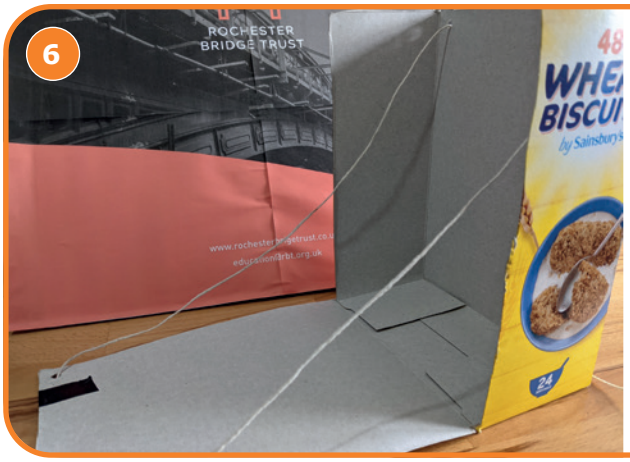
Cut the top flaps from the cereal box.

Using a holepunch, make four holes on the back and front panels of the box, near the corners. Try to space them symmetrically – this could be a little tricky for some learners, so might require adult assistance, especially if using a standard desk hole punch.

Thread the string through the holes: starting from one of the back panel holes, bring the string forward and thread through one of the front panel holes. Then bring the string across the front of the cereal box, and thread it through the front panel hole, before returning through the remaining back panel hole. You should now have a loop of string that runs from the back and across the front.

Thread the string through, leaving a good amount hanging equally from both of the rear holes.

Cut down the sides of the front section of the box, to create the drawbridge – take care not to cut the string as you do this!



You can now draw it up!

Ask learners what they notice about how the bridge moves – where does it get stuck, or where does it move easily? How hard do they have to pull on the string? Is it the same all the way through? If the string is very short and they pull more closely to the back of the box, do they pull more firmly or more gently than if the string is longer and can be held further away?

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Bascule is a French word meaning to tip over or seesaw, which helps to explain how they work. They're counterbalanced by huge weights, that equal the weight of the bridge deck being lifted. Mechanical means can be used to move the weights, such as hydraulics or electric motors. These are attached to a series of cogs and gears, that allow the bridge to move up and down at a slow, managed rate, so the bridge doesn't slam shut.

Image courtesy of Sung Shin on Unsplash

A famous Bascule bridge is Tower Bridge in London.

If you search on YouTube for 'bascule bridge opening' there are a number of different videos showing the process, including Tower Bridge, Pegasus Bridge in Normandy and Erasmus Bridge in Rotterdam. There are also various videos about the bascule chambers of Tower Bridge online, as well as an episode of London's Greatest Bridges on My5, Channel 5's on demand service. A slightly different type of Bascule bridge can be seen in videos of the Johnson Street Blue Bridge in Victoria, British Columbia (Canada). This has a single bascule leaf, rather than two such as Tower Bridge. Other two-leaf bascule bridges can be found if you search for Poole (in Dorset, England) harbour bridges – here there are two very different lifting bridges. One is named the Twin Sails bridge, as when opened, the leaves of the bridge resemble sailing boat sails.

Technically Tower Bridge isn't a straight-forward bascule bridge: it is a suspension bridge, with a double-leaf bascule section for the central deck. This was needed because both the river and the crossings in London were very busy.

In the early period of the bridge, sailors merely had to honk their horn to alert the operator to open the bridge. Now vessels must book the opening in advance.

LIFTING BRIDGE:

A lifting bridge moves the deck up straight up and down, above the river like a lift. They tend to have towers on either side that the bridge moves between on its way up and down. They're suited for wide water ways, where a small section of a low beam bridge can be moved up and out of the way to allow ships to pass, or where railways need to cross the river: the counterweights required to lift the deck vertically are much smaller than those required for a Bascule bridge, for example, as the deck is moving vertically up rather than being lifted at an angle. The main disadvantage of a lifting bridge is that the height beneath the deck is restricted for vessels passing underneath, as the deck remains above the passage (whilst in alternative moving bridge types, the deck moves out of the way almost entirely).

Photo courtesy of "Stuart" 74009 via Wikimedia

An example is the Kingsferry Bridge over the Swale between the Isle of Sheppey and Kent. If you search YouTube for 'Kingsferry lifting bridge Kent' there are a number of videos showing the bridge working.

THIS ACTIVITY DEMONSTRATES THE WAY LIFTING BRIDGES WORK:

1 Make holes in the corners of the thin piece of card, which will be the deck of the bridge, using a hole punch.

2 Cut the flaps from the top of both of the cereal boxes.

3 Punch holes in the front and back of the top of the box.

4 Then also make holes in the front bottom corners.

5 Cut a length of string just over twice as long as the cereal box is tall – for example this cereal box is 25cm tall, so the string used was 55cm. This allows sufficient excess to knot it.

6 Thread the string into the bottom hole that aligns with the card. Loop this up inside the box and bring it out of the top hole. Then bring the string down to towards the deck. Thread the string from the bottom hole in the cereal box up through the hole in the corner of the thin deck card, so it meets the other end of the string, and knot them together. You should end up with something that looks like this.

7 You now need to cut two lengths of string about 1m long. This will be the lifting mechanism for the bridge deck. Loop this through one hole on one side of the deck and knot it. Pass the loose end up through the front hole on the cereal box, then across to the rear hole.

8 Taking your straw, cut it so it fits neatly between the two holes on the back of the box.

9 Pass the string through the straw and then bring it forward through the other rear hole in the box.

10 Make sure the straw is hanging around 4cm below the top of the box, and then loop the string through the hole at the front of the box and then loop it through the deck hole and knot it securely.

11 Repeat this process with the second length of string and straw on the other side of the deck.

12 At this point, you should have a final lifting bridge model. If you carefully pull on the straws and bring them down the back of the boxes, you should see your deck rise! You might wish to add a small weight in the bottom of the box, such as a food tin, some bean bags or a small book, to ensure the boxes don't move too much.

SWING BRIDGE:

This bridge moves horizontally from side to side or around a central pivot to open and close the bridge. The bridge may be attached to the land on one side and when it opens, it moves in an arc out over the river providing a large space across the river for boats.

Original image courtesy of the Royal Engineers Museum collection

The Victorian version of the Rochester Bridge was built to have a swing bridge. The Admiralty (the British governing body at the time responsible for overseeing the Navy and marine affairs) insisted that Sir William Cubitt's design incorporated a ship's passage: a swing bridge that would allow ships with fixed masts to move upriver. It was not powered, but was said to be so well-balanced that two men could easily rotate it around 90 degrees in five minutes.

Some bridges move from a central pivot providing two channels for boats on either side such as the Tyne River Swing Bridge in Newcastle. If you search on YouTube for 'Newcastle swing bridge' there are a number of videos showing the bridge moving. Many of the videos feature the other bridges over the Tyne in Newcastle as well, which may be thought-provoking for learners, to consider why there is a swing bridge at all, or what is different about the swing bridge to the other bridges that allow the vehicles and shipping to pass.

Photo courtesy of Oliver Newbury via Wikimedia

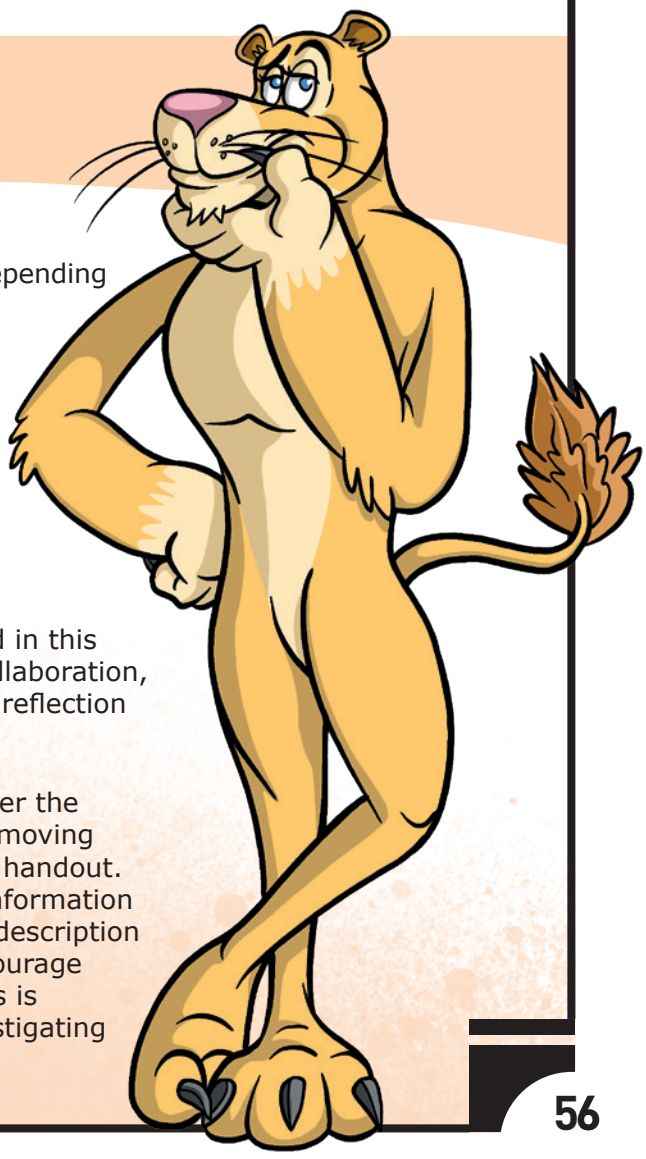
Using the *Moving bridges* handout, learners can compare and contrast the key aspects of each of the bridges from the images and video links shared in this chapter.

Ask learners to consider the different bridges and answer the following questions:

- Why do these bridges need to move?
- What do you notice about how these bridges move?
- What space is needed to allow them to move?
- If this bridge was not available, what other ways might have been used to allow vehicles and pedestrians to cross the water while still allowing boats to sail?

Engineers only use moving bridges when absolutely necessary because they are hard to design, build and maintain. Engineers work out what might work best and Value Engineers work out how to make the project the best value for money. Moving bridges cost a lot to maintain because of the moving parts which can get damaged by use as well as the water and weather. Maintenance of a bridge is a big factor in considering the cost of a bridge.

Challenge Time!



The different styles of the three types of bridge are used depending on the span they need to cross; the size of the boats to pass under and the landscape on either side of the water. Engineers need to spend time testing, designing and modelling their ideas. This includes considering where a bridge might be best placed and the bridge styles that might be suitable, before offering a client some solutions.

Clients have to weigh up what will be the best solution for their water crossing based on functionality, cost, time, maintenance requirements and aesthetics.

Learners can demonstrate their engineering habits of mind in this activity – it is a really good opportunity to demonstrate collaboration, open-mindedness, resourcefulness in problem-soling, and reflection upon the design at the end of the process.

This challenge requires learners to consider the context and brief to select a design for a moving bridge using the Moving bridge challenge handout. The context provides some background information about this challenge. The brief is a short description about what you need to do and why. Encourage learners to use the tips to help them. This is designed to be an enjoyable activity investigating possibilities, not a competition or test.

CONTEXT: You have been given the 'plan' and 'elevation' view of a river where a client thinks they need a bridge.

The client needs vehicles and pedestrians to frequently cross the water at this point on the landscape. The plan view is from above as if you are a bird looking down at the land and water. The elevation view is from the side as if you are in the water looking at the span of the river banks.

The client wants a vehicle and pedestrian crossing here but also needs to allow boats to pass through the water at times.

TIPS:

- As a group you can help each other. Engineers work together in teams to get the best results for their client.
- Consider each possible solution separately and discuss what the benefits and issues of each would be.
- You can use the cardboard and split pins provided to add to the plan and elevation views map and model some ideas.
- Prepare to share your ideas with the other teams at the end of this activity.

BRIEF (WHO, WHAT AND WHY):

The client requests that you make some recommendations about which type of crossing could be most suitable. Using your knowledge of moving bridges and looking at the plans you have been given, consider which types of crossing you might recommend.

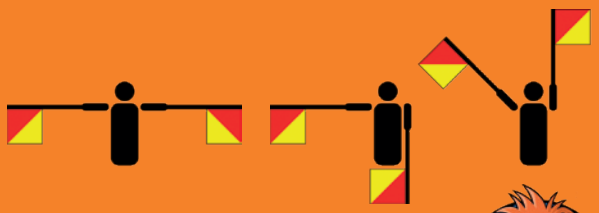
Once the learners have completed their task, it is time for each team to share their ideas and models while explaining what they considered. You could do this with presentations in front of everyone or you could have groups pair up and present to each other. Ask learners to make sure they explain what they thought would work well (or not) and why.

Photo by Andrey Metelev on Unsplash

SOME EXAMPLES OF QUESTIONS YOU MIGHT ASK DURING THIS FEEDBACK:

- Where does the bridge go when it moves? Will space be needed on the land for it when it moves (such as with a Swing Bridge that pivots from one side or the mechanisms of the Bascule Bridge that need space either behind or below the bridge).
- Which bridge styles would least affect the view of the landscape?
- On a narrow river like this how well would a Swing Bridge that pivots in the middle work?
- What other solutions to traffic and pedestrians crossing might there be, other than building a moving bridge here?

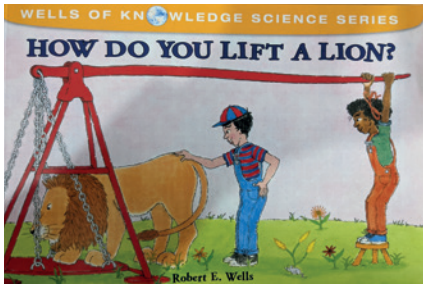
When pilots want to signal for bridges to be opened, nowadays they will likely use radio. However, many moving bridges existed before radios were in common use, so mariners would use semaphore, a signalling system using flags, where the position of hand-held flags mean different letters. These can be found online.



You could learn to send messages to friends, family, classmates – you don't even need flags, you can just use your arms. See what's the longest message you can send!

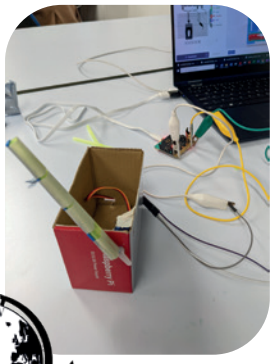
HOT TOPICS!

You could read the book 'How do you lift a lion?' by Robert E Wells. In it the reader gets to find out how simple machines, such as a wheel, lever or pulley, are used to help the children move an amusing assortment of animals.



Tower Bridge is a famous landmark in London, and across the world, as well as being a moving bridge. If you visit the website, there are lots of activities to do including finding out when the lifts are going to happen, reading all about iconic occasions when the bridge has opened, or even do some creative activities, such as making your own moving Tower Bridge picture. You can then use it to make a stop motion film.

If developing basic programming skills, you could use a BBC Micro:bit or Raspberry Pi, servo motor and some basic crafting materials to create a voice activated drawbridge. By creating a simple code to recognise the sound level and respond by moving the motor by a defined number of degrees, it can lift a crafted bridge up and down on command. You could ask learners why this wouldn't be a good idea in real life.



OUT & ABOUT

Moving bridges are quite unusual, so you probably won't see one near where you live… However, maybe when you go out in your local area, you might see other structures that move something from place to place. Can you find out how it moves?

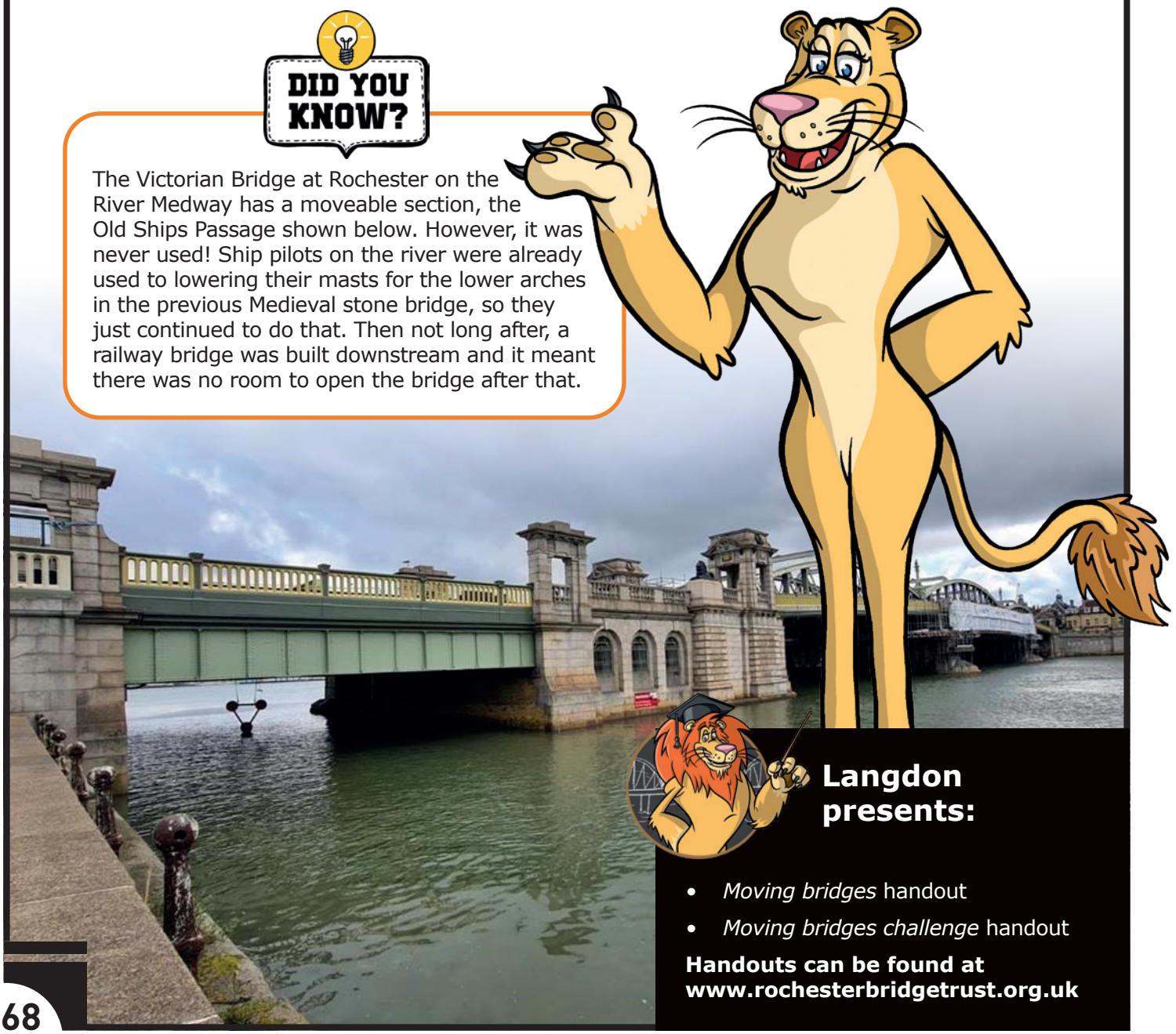
There is an unusual moving bridge in the Paddington area of London. This is called the Heatherwick's Rolling Bridge: more details can be found in the *Interesting Bridge* chapter of this book (online only). Perhaps when you're out and about, you might notice some other unusual moving bridges.

LINK

Photo by Thomas Heatherwick via Wikimedia

DID YOU KNOW?

The Victorian Bridge at Rochester on the River Medway has a moveable section, the Old Ships Passage shown below. However, it was never used! Ship pilots on the river were already used to lowering their masts for the lower arches in the previous Medieval stone bridge, so they just continued to do that. Then not long after, a railway bridge was built downstream and it meant there was no room to open the bridge after that.



Langdon presents:

- *Moving bridges* handout
- *Moving bridges challenge* handout

Handouts can be found at www.rochesterbridgetrust.org.uk