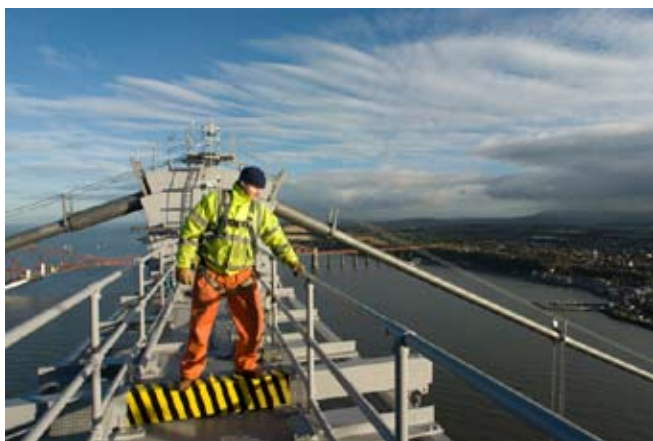


forth road crossing - looking at the bridge

Look at these images of the Forth Road Bridge:



questions to ask

- What kind of bridge is the Forth Road Bridge?
- How do these bridges work?
- What materials is the bridge built from?
- What kinds of problems can you have with these bridges?

think about!

Forces: compression, tension
Materials: steel, cement, stone, composites
How do these materials react with water?

(photos courtesy of Forth Road Bridge)

Angeli Mehta and ESU Scotland for Education Scotland

forth road crossing - behind the scenes

rusting cables

Thousands of tons of road, and all the traffic which crosses the Forth Road Bridge are held up by two immense steel cables. Each cable is over 1km long and is made up of over eleven and a half thousand steel wires, packed together into a bundle about 60cm thick.

In 2004, engineers found that the cables had a serious problem. They are rusting. As the rust progresses, the steel wires begin to break. So while the bridge is still perfectly safe, it has lost about 10% of its strength. The bridge engineers estimated that if the corrosion couldn't be stopped the bridge would have to close to heavy vehicles as early as 2014, and to all traffic by 2019. So began a race against time to try to stop the rust.

the drying process

The plan was to blow dry air into the cables to dry out the moisture, and stop the wires rusting and breaking. But the drying (or dehumidification) process doesn't work instantly. Engineers knew they would have to wait until 2013 to find out whether this process would work. The problem was, if it didn't work there would not be enough time to build a new crossing before the existing bridge had to close.

It was known that drying had been successful on many other suspension bridges around the world. Engineers tested a small section of cable on the Forth Road Bridge and the early results looked promising, so much so that in 2008, engineers estimated the bridge could stay open to HGVs at least until 2017. They also worked out that if the cables didn't dry out enough then it would be possible to replace them, but this would mean traffic disruption for up to 8 years.

the big dilemma

This created a huge dilemma. More than 24 million vehicles use the bridge every year, as many as 70,000 a day. So the question was whether to wait and hope, or get on with replacing the bridge before it potentially had to close?

Between 2006 and 2007 a study was carried out, and in December 2007 the announcement was made that a new crossing would be built. Many groups of people were involved in taking this decision.

If you had been one of them, what would you have decided?

questions to ask

- Why might the bridge have to close?
- Who would be affected if the bridge closed?
- How did engineers know the wires were breaking?
- What could be done to avoid this, and how much would it cost?
- Where have engineering solutions to the problem of rusting already been tried?
- How much would a new bridge cost?
- What would be needed to build a new bridge?
- What other types of bridges can be built?
- What could we do to reduce traffic on the bridge?
- How could public transport be improved?

find out more

Facts about the Forth Road Bridge - see how it was built, see what work is being done and see live traffic reports:

<http://www.feta.gov.uk/home>

Find out how suspension (and other) bridges work:

<http://static.howstuffworks.com/pdf/ups-suspension-bridge.pdf>

<http://science.howstuffworks.com/engineering/civil/ridge.htm>

Click on the video box to see an extract from the BBC series 'Coast' which explores the problems with the bridge:

<http://www.open.edu/openlearn/history-the-arts/history/history-science-technology-and-medicine/history-technology/forth-road-bridge/content-section-1>

How long does it take to plan and build a new bridge?

<http://www.transportscotland.gov.uk/projects/forth-replacement-crossing/timeline>

Short video on carbon dioxide and climate change:

<http://www.bbc.co.uk/learningzone/clips/carbon-dioxide-in-the-atmosphere/4417.html>

Regular project reports on the new bridge:

http://www.roadbridge.ie/pdf/news/FRC_M9J1A_A2_Contract.pdf

forth road crossing - you decide!

it's up to you!

Imagine you have to decide whether to build a new crossing before the present bridge has to close, or wait and hope that the drying process will work. You will need to think about how the building of a new crossing will affect you, and argue for or against a new crossing, depending on your point of view.

planning meeting

You are going to hold a planning meeting to decide whether or not to build a new crossing. You will be working in groups and each group will look at this question from a different point of view. You'll need to work together in your team to discuss what your group's point of view should be at the meeting and what information you will need to research. You should also think about what areas you are willing to concede in negotiation. You should choose a member of your group to make a speech at the meeting to describe the views of your group. During the meeting, other group members will be part of the audience and will be able to make comments and ask questions after the speeches.

preparing for the meeting

Once you have looked at your role card and talked together about what you think your main arguments will be, you will need to go and do your research. You should divide this up in the group so that the research work is shared out between you all. When you come to write the speech you will all need to come together with your ideas and information. Remember that your speech needs an introduction with a preview of what you are going to say, and a conclusion with a summary of your main points. All your main points should be R.E.A.L. arguments:

- Start with a **reason** - say what your point is clearly and concisely
- Follow this with an **example or evidence** that underlines the point - this is where you need to have done your research!
- Provide **analysis** which explains why your point is important, what the consequences might be
- And **link** it back to the question - remind everyone which side you are on!

the meeting

At the meeting, the Chair will call the meeting to order and introduce the various groups and the representative from each group. Each representative will be called on to make their speech, explaining their group's position and giving their suggestions for a fair outcome. Then the Chair will take questions from the audience. After the questions, each representative should give a brief summary of their position and favoured outcome. At the end of the Summary Section, the Chair will make a list of points that all the representatives agree on and ensure there is a definite outcome. However, in some circumstances, groups will not come to an overall agreement and the Chair will then hold a vote to decide on one of the outcomes.

possible outcomes

- A new bridge is approved
- A new toll bridge is approved, with the toll income used to fund public transport.
- No new bridge: money for repairs to existing bridge
- Approval for rail and passenger freight improvements and a study into incentive schemes to encourage car sharing.

the forth road bridge - your roles

road transport group

favours the building of a new bridge

- Around seventy thousand vehicles cross the existing bridge each day: it is a vital link in Scotland's transport network.
- At peak time in the morning and evenings, there are lengthy delays on the existing bridge.
- The bridge needs a lot of maintenance work which is very disruptive and only makes congestion worse as lanes have to be closed.
- If the cable drying programme does not work, the bridge will be closed to all traffic within a few years: this will be disastrous for commuters and the movement of goods across the Forth. Vehicles will have to be re-routed via the Kincardine and Clackmannanshire bridges, adding up to 40 miles to each journey, and major congestion problems.
- The congestion from delays, bridge works and traffic re-routing all mean more carbon emissions.

public transport group

opposed to the building of a new crossing

- The existing bridge is in need of repairs partly because of huge numbers and weight of Heavy Goods Vehicles (HGVs) which use the bridge. The weight of HGVs has almost doubled since the bridge was opened.
- The cost of repairs is just a fraction of the cost of a new bridge - the difference could be better spent on improving rail links and encouraging HGVs off the roads.
- Invest in public transport so people don't have to get in cars (many vehicles just have one person) which means the journey is expensive. This would also be good for the environment.
- There is commercial interest in developing a ferry service between Kirkcaldy and Leith.
- Jobs will be created by new transport schemes and through the bridge repairs.

environment group

opposed to the building of a new crossing

- Carbon emissions are already forecast to rise by 23% by 2022. Building a bridge will increase carbon emissions, for example the steel will come from China and EU.
- A new bridge will mean more traffic (and more CO₂). It is estimated that the new bridge will be at capacity by 2031.
- Government targets to reduce traffic by 2021 to 2001 levels will not be met.
- Building the bridge will damage habitat for birds and animals; ancient woodland will be lost; more housing will probably be built which will also mean less green spaces.

economy group

favours the building of a new bridge

- Prestigious new capital project will mean up to 1,200 new jobs, and more work for companies.
- Transport for Scotland research estimates that the project will bring economic benefits worth £6 billion. If cables were replaced on the existing bridge, economic output would fall and jobs would be lost.
- Closing old bridge with no replacement would be economic disaster.
- The new crossing will improve transport links and allow more people to live outside the city, which will create more jobs: building homes etc.
- Congestion on the existing bridge already costs businesses money in delays and more fuel used.

chair

- Calls the meeting to order and explains the purpose and possible outcomes of the meeting.
- Invites group representatives to speak and makes sure they speak for their allotted time.
- Introduces and controls the floor debate.
- Introduces the summary speeches.
- Announces the areas of agreement (if any) between the groups and introduces a vote (if desired).

reporters

- Keeps notes of everything said at the meeting.
- Asks questions during the questioning period.
- Prepares a report for the next class as part of homework. This can be in the style chosen by the student (tabloid, broadsheet etc) or in a style assigned by the teacher. Alternatively, students can prepare a podcast.

forth road crossing - the new bridge

A new bridge was approved and work started on it in autumn 2011. These images are artists' impressions of what the new bridge will look like.



drying out successful!

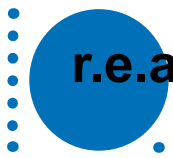
A system to dry out - or dehumidify - the cables was installed on the bridge in 2009. In February 2013, after engineers had inspected the cables, they reported that the problem of rusting appears to have been resolved.

As long as the dehumidification system keeps working, then the cables will remain safe. The damage done to the wires before the drying out system was installed cannot be repaired and the cables will have to be continually checked and monitored.

questions to ask

- How does dehumidification work?
- How do engineers know that the bridge is safe?
- Now that drying has worked, do we still need a new bridge?
- What do you think of the new design?

(photos courtesy of Transport Scotland)



r.e.a.l. guide and sample speech structure

introduction, preview, rebuttal of other speakers' points

reason

example/evidence

analysis

link

reason

example/evidence

analysis

link

reason

example/evidence

analysis

link

review of main points and conclusion



forth road crossing teacher's notes 1

Introduction

The topic can be used for either a formal debate or a role-play. Both formats will require pupils to research different aspects of the topic thoroughly and plan and build their arguments. The [find out more](#) section of the factsheet directs pupils to websites that will provide plenty of material and information.

The most successful way to integrate this activity into your teaching is to spread the activity over 2-3 lessons to ensure that pupils have plenty of time to think, research and plan. Pupils will benefit much more from this method and it will help to shift the main focus from the debate itself (which will be the highlight for many pupils) to the whole process of independent and collaborative learning: research, weighing up evidence, developing coherent and convincing arguments, and finally evaluating and using what they have discovered.

Science links

Forces: compression, tension Materials: steel, cement, stone, composites Chemistry: what causes rust?

Lesson 1: Planning

In class:

Introduce the topic and some general discussion around the background information and questions on the factsheets. What do they already know?

Worksheet 1: Looking at the bridge

This worksheet is designed to introduce the topic. The questions direct pupils to consider some of the problems associated with suspension bridges. Direct pupils to the [think about!](#) box to help them consider potential problems with metal bridges: rust, weakening, the weight of the bridge itself and that of the vehicles, etc.

Worksheet 2: Behind the scenes

This worksheet provides a context for the role-play and background information that the pupils will need. Some of the questions can be answered from the text, but for some questions pupils will need to look at the sources listed in the [find out more](#) section. This will provide a start for the research they will need to do for their roles. Pupils could start this research in class or at home for homework. Alternatively, pupils could look at these questions once their roles have been allocated.

Worksheet 3: You decide! & Worksheet 4: Role cards

First, explain the scenario and encourage pupils to think what the main issues and points of view might be. Ask pupils who would be affected by the building of a new crossing. Would these groups be for or against a new crossing? Divide the pupils into five groups, one for each of the four main roles, and one group which will become the chair and reporters group.

In their groups, pupils should work together to discuss what the group's point of view should be at the meeting and what information they might need to research. They should also think about what areas they are willing to concede in negotiation. At this stage the Chair and Reporter group should take a neutral viewpoint and consider what they think will be the main areas of contention and brainstorm and research general questions to ask during the meeting. Give each group their role card. You may want to encourage pupils to think about the positions of the other groups involved. There are brainstorming ideas at the end of these notes which you could use to help the groups think of points.

For the role-play itself, each group should allocate a member of the group to make a speech at the meeting to describe the views of that group. Emphasise that ALL pupils have a part to play, not just the speakers.

At home:

Pupils should divide up points to research for their group and plan their speeches.



forth road crossing teacher's notes 2

Lesson 2: Debate

By this stage the pupils should have a good idea of their main arguments and have done the research to find evidence to support their case.

In class:

Remind the pupils about making their arguments R.E.A.L. If you haven't done so already, go through speech structure with your pupils. This will help them to refine their arguments and structure their speeches. Pupils can then pool their ideas from their groups to finish writing their speeches. (This could have been done for homework). Encourage them to make notes and bullet points rather than writing the speeches out in full. This will help to avoid reading their speeches, which will make the speakers more persuasive and help them to interact with the audience more effectively.

From the Chair and Reporters group you will need to allocate the following roles:

Chair: See role card

Timekeeper: Times each speech and notes down the amount of time each speaker spoke for (it is up to you to decide how long the pupils can speak for - we suggest a time limit of 3 to 5 minutes)

Reporters: See role card

During the meeting the extra members of the main groups will make up the audience. They can ask questions following the main speeches. You may wish to set a time limit for this section, e.g. 10 minutes.

After the debate you may want to hold a vote to decide which outcome will follow. You may wish to encourage a free vote rather than pupils being tied to their team's policy.

Lesson 3: Follow-up

In class:

A lot of the research, learning, and understanding will have taken place during the preparation and debate stages, but the follow-up stage is important to review and consolidate what has been discovered.

Start by discussing the main points with your pupils. Did the most important arguments come out during the debate? Were there any surprises? Was the outcome as expected? What have they learnt during the process?

Worksheet 5: The new bridge

This worksheet rounds off the topic by showing the plans for the new bridge, and also explains that the dehumidification process has worked. The questions help pupils to consider whether they would still choose the action they decided on, and could be set as homework.

Optional extension tasks:

There are various ways that the information gathered can be recorded. Here are some ideas:

- Posters for the classroom showing the main arguments and facts.
- Newspaper style reports, or article for the school newspaper/magazine/website
- A report for assembly or a podcast for the school website
- Discursive essays, based on the debate
- Write a (sample) letter to your MSP or local newspaper explaining your decision

Suggested motions for a formal debate format

- This house would build a new Forth road crossing
- This house believes that public transport should be improved before any new Forth crossing is built

forth road crossing - brainstorming ideas

for a new crossing

Environment

- Congestion on the existing bridge adds to carbon emissions:
 - the existing bridge is in need of major repairs, so there will be congestion while lanes are taken out of use
 - if the cable drying fails and the bridge closes, then traffic emissions will increase due to the increased journeys via the Kincardine and Clackmannanshire bridges (adding up to 40 miles)
 - if the cables have to be replaced then we face 8 or 9 years of delays, leading to more congestion and more emissions
- The new bridge approach roads have a traffic management system which will set speed limits to 'smooth out' traffic flow - so lower carbon emissions for the same amount of traffic
- Great care will be taken to protect marine and plant life at the site. More trees will be planted than cut down.
- The new bridge design is attractive and will complement the existing crossings.
- More walkers and cyclists are likely to use the old bridge.
- Many green spaces surrounding the crossing will be preserved.
- Most disruption is during construction so will only be temporary.

Economic

- Too risky to wait to see if the cables are drying- the economic impact of the bridge closure would be devastating.
- Cable replacement would mean major traffic disruption for 8-9 years - again the economic impact would be too great.
- Scotland needs a new capital project, leading to prestige and jobs. The British Chambers of Commerce predict economic benefits worth £6bn and 1200 new jobs.

Transport

- The existing bridge is congested, and any extra work will add to this. We need a new bridge to deal with current traffic volume. The existing bridge is sometimes closed or has speed restrictions due to high winds. The new bridge will have a wind protection system and also a hard shoulder so broken down vehicles will no longer block traffic lanes: less congestion.
- We need the bridge because public transport links are poor, for example trains are not frequent enough.
- There is not enough rail capacity or hubs for freight.
- We need new homes. The bridge will improve transport links and allow more people to live outside the expensive city, improving social networks.
- It's not just cables that are the issue: there is concern over rusting in the anchors that keep the cables in the ground, plus ongoing work on the deck, joints etc. It requires a major programme just to keep the bridge going.

against a new crossing

Environment

- Building a new bridge will increase carbon emissions, both through traffic and materials (steel, cement), for example, the steel will come from China and EU.
- The increased volume of traffic will not help meet government CO2 targets. (According to Sustran, CO2 transport emissions are already forecast to increase 23% by 2022.)
- By 2031 the new bridge will be at capacity for peak journeys.
- More traffic brings potentially reduced air quality leading to health problems; noise pollution during construction and increased noise for residents living near the new bridge
- Damage to Site of Special Scientific Interest: habitat loss to birds; loss of ancient woodland; loss of habitat and disruption to species such as otters and bats. Land will be taken out of agricultural use.
- Impact on view across Forth.
- The new bridge will encourage more housing, meaning more green spaces will disappear.
- Coastal footpaths will be lost.

Economic

- The huge costs involved are unnecessary. Drying has worked on other bridges around the world and seems to be working here. Cable work costs a fraction of the cost of a new bridge/road infrastructure.
- Engineers have worked out how to replace the cables for a fraction of the cost of building a new bridge.
- Jobs will be created through repairs, and by investment in public transport which would be more sustainable. Predicted economic benefits through reduced travel times are often over-optimistic.

Transport

- With increased capacity on the new bridge, where will the increased traffic volume go? Edinburgh's roads are already congested.
- The Scottish Government traffic targets (to peg 2021 traffic levels at 2001 levels) may not be met if we build a new bridge.
- The money saved by not building a new bridge could be used to improve public transport (buses, rail) and discouraging single occupancy car use. No growth in public transport is predicted over old bridge.
- The weight and number of HGV vehicles are a problem. Improving rail freight options could remove HGVs from the bridge and improving public transport could take vehicles off bridge.
- There will be noise and disruption during construction.