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| **Lesson Ten: Thomas Telford** | |
| Lesson Ten focuses solely on Box 4 and the life of Thomas Telford. Telford was a designer and civil engineer who over a twenty year period embarked on a building project that involved constructing over nine hundred miles of roads and over a thousand bridges to create links between towns across the Highlands. He designed and oversaw the construction of the Caledonian canal as well as hundreds of harbours and slipways. Telford’s impact on the Highlands is immeasurable and hopefully this lesson can form an introduction to a hugely important figure in Scottish history. | |
| **Curriculum Links - Social Subjects (People, Past Events and Societies)** | |
| Experiences and Outcomes | Benchmarks |
| I can evaluate conflicting sources of evidence to sustain a line of argument. SOC 4-01a  I can present supported conclusions about the social, political and economic impacts of a technological change in the past. SOC 4-05a  I can evaluate the changes which have taken place in an industry in Scotland’s past and can debate their impact. SOC 4-05b | * Demonstrates the ability to provide a valid argument on a historical theme. * Provides at least two valid opinions to support  the argument. * Identifies the impact of a technological change with at least one of each: social, political and economic impacts and gives a reason for the conclusion. * Suggests at least three changes which have taken  place in Scotland’s industry. * Provides at least two positive and negative impacts of one of these changes. |
| **Wider Curricular links** | |
| **Technologies (Application of Engineering):**  I can solve problems through the application of engineering principles and can discuss the impact engineering has on the world around me. **TCH 4-12a** | |

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| **Learning Objectives** |
| To explain the impact of Thomas Telford’s work on the economic and social development of Scotland/Highland. |
| To build/simulate solutions to engineering problems. |
| To explain, using correct technological vocabulary, the engineering processes involved in the design and construction of bridges. |

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| **Resources and Suggested Reading** |
| **Required Resources - Supplied in the boxes** |
| Objects: Allt na Fearna Mor bridge model, Arch blocks (Box 4)  Information Sheets: Thomas Telford, Allt na Fearna Mor Bridge, Additional images: Thomas Telford’s Road Network, Thomas Telford Bridges in the Highlands |
| **Additional Required Resources** |
| Dried spaghetti, midget gems or marshmallows, cardboard, Sellotape, paper, tea tray or Tupperware container, tennis ball or sponge ball, ICT equipment, google maps, Post-it notes, List of Telford churches [[link](https://en.wikipedia.org/wiki/Telford_Parliamentary_church)] |
| **Essential Reading - Information sheets supplied in the box or from ARCH website** |
| Thomas Telford object sheet |
| **Suggested Additional Reading - Information sheets supplied in the box or from ARCH website** |
| None |

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| **Introduction** | | **15 minutes** |
| **What is engineering?** (5 minutes) | Resources: None | |
| * This introduction focuses on what engineering is and the role of the engineer. * There is scope to expand this introduction and conduct research on local feats of engineering. | | |
| Display the following definition of engineering on the board:  **“The branch of science and technology concerned with the design, building, and use of engines, machines, and structures.”** Explain that engineering refers to the science that ensures buildings, bridges and other structures stay standing.  Ask ***Knowing what engineering is, what does an engineer do?***  Finally finish by asking the class what special buildings, bridges, canals or other structures they have noticed in their local area, some of which could possibly have been designed by an engineer. | | |
| **Portrait** (10 minutes) | Resources: Thomas Telford object sheet | |
| * This section is a brief introduction to Thomas Telford. * The portrait of Telford by S. Lane has a number of small details that, when studied closely, hint at some of Telford’s achievements. | | |
| Show the class the portrait of Thomas Telford by S. Lane (on the back of the Thomas Telford object sheet). Don’t tell the students who the person is. Instead split them into pairs.  Split the class into pairs and write the following questions on the board (the answers are provided in brackets).   * ***When do you think this person lived?*** (Around two hundred years ago - b. 1757 & d. 1834) * ***What can you see in the picture?*** (A viaduct in the background, sheets of paper on a desk) * ***How old do you think he is when he sat for this portrait?*** (It was published in 1831 when Thomas Telford was 74) * ***What do you think his job was?*** (Engineer)   Explain to a class that you can tell a lot from a portrait and they sometimes contain additional information. Give the students a couple of minutes to discuss their answers and then share them with the rest of the class.  Explain to the class that the subject of the portrait is Thomas Telford, a notable civil engineer who left a lasting legacy on the Highlands of Scotland and was responsible for some of the most ambitious civil engineering projects of his age. | | |

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| **Main** | | | | **30 minutes (without optional tasks)** |
| **Who was Thomas Telford?** (15 minutes) | Resources:  Information Sheets: Thomas Telford object sheet; Additional Image: Thomas Telford Bridges in the Highlands  Other Resources: Paper, ICT access | | | |
| * These activities are designed to introduce the work of Thomas Telford to the class. It is possible some students have never heard of him and therefore will know nothing about his life and work. * Thomas Telford had a huge impact on life in the Highlands. | | | | |
| If your students have individual access to the internet begin the main section of the lesson with a quick research exercise. Allow all the students to log onto the internet and then display this on the board: ***You have three minutes to find as many facts about the Caledonian canal as possible.*** If there are issues regarding additional support needs you can complete this section as a paired exercise.  Once the time is elapsed have the students share the facts they have found with the rest of the class. Focus on the designer of the canal who, as most students should know at this point, was Thomas Telford.  If your class does not have access to internet, this first activity can be completed as a short discussion session*.*  ***OPTIONAL****: Telford was also involved in the construction of the Dingwall canal (as well as other canal projects across the British Isles and Sweden). It was not a commercial success and was relatively short lived. It would make an interesting short research task for the students to consider.*  It is likely the following information came up as part of the research task. If so recap with the class that the Caledonian canal is sixty miles long and links the east coast of Scotland at Inverness to the west coast near Fort William. It has 29 locks, four aqueducts and ten bridges which were all built as part of the project. The canal took nineteen years to complete.  Show the class bridges designed by Thomas Telford. A sheet with four bridges is supplied, and a simple internet search of the term “Thomas Telford Bridges” will bring up other examples. It is worth focusing on these three:   1. Telford Bridge, Invermoriston 2. Menai Suspension Bridge 3. Pontcysyllte Aqueduct   Two of these bridges are in Wales but are excellent examples of impressive structures design by Telford.  Divide the class into mixed ability groups of four (three will also work). Hand out the Thomas Telford information sheet. Give each student in the group a number from one to four. If you have students who need additional support with their reading make sure they are number one which will mean that you can support this group.  Number ones are to read the first paragraph. Number twos are to read the second and third paragraphs, number threes the fourth and fifth paragraphs, and number fours the sixth and seventh paragraphs. Give the students a reasonable time limit (two minutes usually works but it depends on the reading level of the class). During this time the students are to read their section and summarise the information. When the time has run out give each student thirty seconds to summarise their section to the rest of the group.  ***OPTIONAL****: There is the opportunity to conduct further research in the life of Thomas Telford. Using ICT, the students could write a fact sheet adding to the information they learnt from the information sheet. There are links and suggested further reading provided below in the “Links and Further Information” section.* | | | | |
| **Thomas Telford in the Highlands** (15 minutes) | | | Resources:  Information Sheets: Additional Image: Thomas Telford’s Road Network  Other Resources: ICT, google maps, List of Telford churches [[link](https://en.wikipedia.org/wiki/Telford_Parliamentary_church)] | |
| * Telford’s impact on the Highlands is difficult to quantify. However, many of the structures he created are still in use today. * This activity is a self-led research task with the students finding the information to complete a quiz. | | | | |
| Thomas Telford had a huge impact on life in the Highlands. His various projects and innovative designs have left a lasting legacy across Scotland.  Show the class the image of the map taken from Thomas Telford’s autobiography showing the roads he built in red. Show the class (side by side on the board) the A82 between Inverness and Fort Augustus on the board using google maps. Ask the class ***What do you notice about the modern roads shown on google maps, and the roads created by Telford?*** A lot of the roads Telford built form the basis of the modern road network. Follow up with the question ***What does this tell you about the roads and bridges Telford created?*** His methodical surveying and engineering prowess have meant his creations have lasted hundreds of years.  Show the class the image of the Poolewe church on the information sheet. Ask the class to describe one point of interest that they notice with a partner. Have the students share some of their ideas with the rest of the class. Remind the students that Thomas Telford was commissioned by the government to build over thirty churches in the Highlands. His design could be adapted to suit different areas and were relatively cheap to build.  ***OPTIONAL****: This is an optional mapping activity related to the Parliamentary churches. Using the list of Telford Churches [*[*link*](https://en.wikipedia.org/wiki/Telford_Parliamentary_church)*] the students are to find the locations of Telford Parliamentary Churches throughout the Highlands.*  *The students could use old OS maps on the National Library of Scotland website (which can be found here:* [*https://maps.nls.uk/*](https://maps.nls.uk/)*) to locate the churches. By using google maps and street view in conjunction with the old OS maps they can explore the current use of the churches Telford built. By dividing the churches between the class they will be able to find most of the surviving buildings. You could focus on those closest to the school and have the student’s feedback on what they have learnt. For example, the church built in Ullapool now houses Ullapool Museum.*  Write this question on the board: ***What impact did Thomas Telford have on life in the Highlands?*** Using the information sheet and their own additional research, have the students answer the above question in a short essay format. Below are the main points that may be covered:   * Telford’s road network provided better transport options for communities across the Highlands. * The surveying of the routes and the design of the roads was vital to their success. * Modern roads still follow the routes laid out by Telford. * His projects provided work for local families and reduced emigration out of the Highlands. * The Caledonia Canal meant that shipping could avoid the treacherous passage around the north of Scotland. * Many of Telford’s bridges survive today and some, such as Bonar Bridge had a major impact on the communities living around it. | | | | |
| **Allt na Fearna Mor** **OPTIONAL** (30 minutes) | | Resources:  Objects: Allt na Fearna Mor bridge model  Information Sheets: Allt na Fearna Mor Bridge object sheet; Archaeological Survey of Allt na Fearna Mor Bridge report | | |
| * This activity focuses on an archaeological survey of two potential Telford designed bridges. * The survey itself is a piece of technical writing and contains specific vocabulary which will need to be covered as part of the task. | | | | |
| This part of the lesson is optional because, while it requires the students to interpret an archaeological survey on the bridges, there is a lot of interesting information contained within the report, however, it requires you to introduce some specific vocabulary to aid the students.  Show the class the model of Allt na Fearna Mor. Explain that this is a bridge designed by Telford and recently surveyed by ARCH (2014). It is one of over one thousand bridges built by Telford as part of the Highland road building project.  ***OPTIONAL****: Hand out the Allt na Fearna Mor Bridge information sheet for the students to read a brief introduction to the bridge. This is optional as this section of the lesson focuses on an archaeological report on the bridge itself.*  Divide the class into pairs or small groups. Hand each group the archaeological survey report. Have the groups divide the document into sections; each student is to be responsible for one of the sections. Using highlighters, have the students identify the vocabulary they are not familiar with. From there, as a class, you can create a glossary of terms to aid with the task using the internet to find the required definitions.  Next write the questions ***What evidence is there to suggest that the two bridges were designed by Telford?*** And ***Why is knowing whether the bridges formed part of Telford’s road building project important?*** (If the bridges are part of Telford’s scheme, it would add weight to the case presented for their preservation).  Throughout the document there are a number of findings from the survey which suggest a potential link with Telford and these are detailed in each section. However they are contained within fairly detailed survey information so they are not necessarily easy to dig out.  When the students have found the supporting evidence it can be presented in a number of ways:   * A simple class discussion. * Informal verbal presentation. * Formal presentation with supporting resources. * A short written essay detailing the evidence and answering the above questions. * As part of a wider debate on the benefits of preservation over the potential costs. | | | | |
| **Engineering** **(OPTIONAL)** (40 minutes) | | Resources:  Objects: Allt na Fearna Mor bridge model, Arch blocks (Box 4)  Other Resources: dried spaghetti, midget gems or marshmallows, cardboard, Sellotape, paper, tea tray or Tupperware container, tennis ball or sponge ball | | |
| * This is a practical session which challenges the students to complete some engineering type tasks. * One group will work with the teacher to discuss the Allt na Fearna Mor Bridge model and the constructions of arches. | | | | |
| *These following activities are completely optional; they are interactive, co-operative-based tasks and would work well as team building tasks with a worthwhile learning context. Therefore, they are worth finding the time to build into the lesson (or completed as a separate lesson) as they provide unusual challenges for the students in your class. Additionally these tasks can be extended fairly easily. For example, the bridge building activity could have an additional engineering focus (triangular designs, tensile strength, etc.)*  *Depending on numbers, split the class into three or six groups (groups of three or four students is ideal). This part of the lesson features three separate activities which the groups rotate around. These activities are to be completed at the same time and repeated as the groups move around. Explain each activity at the beginning so all students know what they are to do at each point. These activities can be split up and completed in separate lessons if you wish. All three are designed to challenge students to create structures and consider engineering principals when designing solutions.*  **1. Spaghetti and Midget Gem bridge**  In this task students are to try and span an 80cm gap between two tables with a bridge made entirely from dried spaghetti and midget gems (marshmallows will work as well). It is important to store the midget gems in a warm space (near a radiator is perfect) as this will make them a little softer and make it easier to push the spaghetti into the sweet.  The bridge needs to be free standing and cannot be attached to the tables in any way (usually students will try and use sellotape); instead the bridge will need to “rest” or “hang” on the table surface. The bridge also needs to include a 5cm wide cardboard “road” for a vehicle to travel across.  To test the bridge you can either:   * Run a vehicle (there is one supplied in the box, but you may want to try some heavier ones) of a certain weight over the bridge to see if it survives. Record the number of spaghetti pieces that have been used in the bridge (broken pieces still count as one). The bridge that survives and uses the least pieces is the winner. * Add weights to the base of the bridge until it collapses. The bridge that could hold the most weight is the winner.   **2. Ball run (analogous to slipways)**  This activity requires A4 paper and sellotape, but it can be completed with scrap paper or old worksheets to ensure paper is not being wasted.  Each group is to try and move a ball (either a tennis ball or sponge ball) from on top of a classroom table to a container, resting on a student chair one metre away, without the ball touching the floor. A tea tray with low sides works really well for this activity because if the ball hits the tea tray too quickly it will bounce out and therefore hit the floor. This means the group will need to think of the angle of their slipway. If you want to make this activity slightly easier using a Tupperware container will also work.  Give each group one metre of sellotape and ten sheets of paper (again if you wish to make the task easier give each group more paper and sellotape). Only the supplied sellotape and paper can be used. If any other material is used in the construction then the group are disqualified.  If more than one group manages to complete the ball run then the team who used the least material is the winner.  **3. Allt na Fearna Mor bridge**  This activity is teacher-led and involves the bridge model and the wooden arch pieces from Box 4. Show the students the model bridge. Ask ***What type of bridge is it?*** Explain that the stones of the arch have been shaped to fit into place. Show the students the wooden “former” under the archway. Explain that this was used to shape the archway, and would have been made up of a framework of cut timber. The stones would be built on the former until the final central stone (keystone) was placed at the top of the arch. Once it was in place the former could be removed. You can demonstrate this with the model.  Give the group(s) the pack of large wooden blocks. Ask the group(s) to build an arch using the wooden blocks. When the archway is complete, ask the groups to test how strong it is. Have one student push down on the middle top stone (given enough force the archway should collapse). Have the students rebuild the arch. Ask ***How can we stop that happening?*** Demonstrate the strength of a correctly built arch by asking two students to hold the bottom stone on each side. Make sure they are only holding the bottom block. Have a student push down on the middle stone again. It should be obvious, if done correctly, just how strong an archway is.  Explain to the class groups that arches are incredibly strong. All the load pressing down on the bridge is directed down either side of the archway. The lower stones are supported by abutments which prevent the bottom stones from being forced outwards.  Return to the model. Show the key stone and the abutments on the model. Explain that this was a typical arched bridged designed by Thomas Telford and is a model of Allt na Fearna Mor bridge near Invershin (south of Lairg). It is one of thousand plus bridges that Telford built during his Highland road project in the early 1800s.  *Ten to fifteen minutes is a reasonable length of time for each activity. Show a timer on the board and when it has elapsed move each group to the next activity. During the changeover you can inspect each group’s work. This is a good time to test the bridge and ball run. The results can then be recorded on the board and collated at the end of the lesson. You could incentivise the groups with a prize but that is obviously up to you.* | | | | |

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| **Plenary** | | **5 minutes** |
| **Ask a question** (5 minutes) | Resources: Post-it notes | |
| * This plenary is simply a reflective exercise to generate discussion of the students’ learning. | | |
| Give each student a post-it note and have them write on it a question they would like to ask Thomas Telford if they could. Once the students have written their question they are to stick it on the white board. Share some students’ questions with the rest of the class.  Following that, as a *think-pair-share* exercise, ask the students ***what are three interesting points you have learnt during the lesson?*** Collate the class’s answers. | | |

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| **Total Lesson Time: 50 minutes (without optional tasks)** |
| **Links** |
| ARCH Experimental Archaeology Project: [www.archhighland.org.uk/experimental-archaeology.asp](http://www.archhighland.org.uk/experimental-archaeology.asp)  There is a video about Telford and a blog.  The ICE (Institute of Civil Engineers) booklet “Invisible Superheroes” can be found in the box (until they run out) and can be downloaded from the Lesson Resources . More information about ICE can be found at <https://www.ice.org.uk/> On line Resources [Biography](http://doi.org/10.1093/ref:odnb/27107) by Roland Paxon of ICE in Oxford Dictionary of National Biography, updated in 2013. This gives details about Telford and his works.  There are also a wealth of articles, pictures and other material about Telford on line – too many to list here! The [Highland Historic Environment Record](http://her.highland.gov.uk) (HER) and [Canmore](http://canmore.org.uk) both record information about Telford buildings, piers, harbours etc.  List of Telford churches <https://en.wikipedia.org/wiki/Telford_Parliamentary_church>) Books and articles Commissioners for Highland Roads and Bridges Reports. The full set is in Inverness Reference Library, while Reports 1-9 and 20 onwards are in Highland Archive Centre. This is an invaluable source detailing progress and developments through the years.  Curtis, G.R. 1978-80. ‘Roads and bridges in the Scottish Highlands: the route between Dunkeld and Inverness’, Proceedings of the Society of Antiquaries of Scotland vol. 110, 475-96. Although focussing further south, it still has a good summary of Telford’s activities and a typology of his bridges. Available Inverness Reference Library, Dingwall Library or [on-line](file:///C:\Users\Dave\AppData\Local\Packages\microsoft.windowscommunicationsapps_8wekyb3d8bbwe\LocalState\Files\S0\1622\Attachments\archaeologydataservice.ac.uk\archives\view\psas\contents.cfm%3fvol=110&CFID=92dd8541-1bcc-466f-8542-ac59539107bd&CFTOKEN=0).  Haldane, A.R.B. 1962.New Ways through the Glens. The best overview of Telford’s activities. Available in some Highland Libraries.  MacLean, Allan 1989. Telford’s Highland Churches. Available in some Highland Libraries.  Paxton, Roland (ed.) 2007. Thomas Telford: 250 years of Inspiration. A very useful booklet published by ICE and available from their bookshop. Many of the articles are available on line.  Southey, Robert 1929. Journey of a Tour in Scotland in 1819. London: John Murray. Also available on the internet. Invaluable account of travels just after Telford had completed his works – but biased, because Southey was a close friend of Telford.  Telford, Thomas ed. John Rickman 1838. Life of Thomas Telford, Civil Engineer. Telford’s autobiography completed after his death by John Rickman. Contains large atlas with many drawings. Available Inverness Reference Library. Archives The Highland Archive Centre in Inverness has a wealth of archive material on the Caledonian Canal, as well as some Telford plans and other materials. It also houses the local council roads committee minutes which often mention Telford and his work.  Other archives relating to Telford’s work are scattered throughout the country but include National Records of Scotland in Edinburgh, The National Archives at Kew and the Parliamentary Archives at Westminster. |

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