



The Engineering Process

AIMS & OBJECTIVES

- To know what we mean by civil engineering
- To recognise the engineering design process
- To apply some of the engineering design processes to a task

CONTEXT

Engineering is work that uses science, maths and technology to create products and processes. Engineers work in all types of settings all over the world, sometimes alone and sometimes in a team. The engineering design process is a set of steps an engineer follows to go from an idea or a need, to a product or process.

LANGUAGE OF BRIDGES:

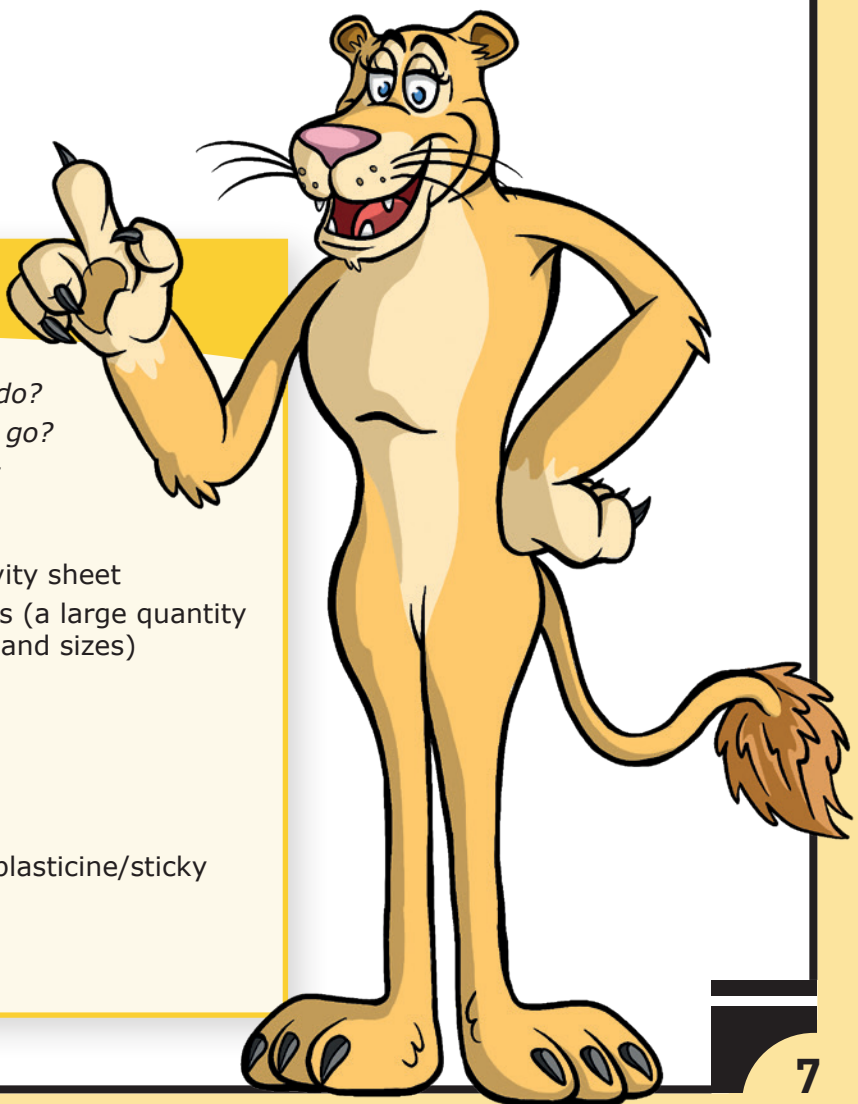
Civil engineering: the type of engineering that helps shape the world around us, helping to design bridges, tunnels, railways, roadways, as well as constructing skyscrapers, dams, power stations, airports and sports stadiums.

Engineering design process: the process engineers use to describe the steps taken to move from a question, idea or need, to designing the product or process required.

Iron triangle of engineering: a way of showing how three factors in engineering projects affect each other.

You will need...

- Handout: *What do Civil Engineers do?*
- Handout: *Where should the bridge go?*
- Handout: *Bridge builder's checklist*
- Can you build it? (per group)
 - Handout: *Can you build it?* Activity sheet
 - Standard wooden building blocks (a large quantity with a good selection of shapes and sizes)
- Design Challenge (per group):
 - 100 wooden toothpicks
 - 50 jelly sweets
 - Sewing thread
 - A small lump of modelling clay/plasticine/sticky tack, for the base
 - Paper and pens/pencils
 - Handout: *Design Challenge*







It starts with someone asking a question. This identifies the problem or the constraints of the engineering project. Then engineers start to imagine possible solutions, and start to design and plan their project, gathering research and brainstorming ideas. Once an engineer has a plan, they can start to build – this is usually a model or prototype of the project. This can then be tested to check whether the project actually achieves what it set out to do: if it doesn't, the design is refined, re-built and re-evaluated. The final project can then be shared and the cycle starts all over again!

Civil engineers have to consider lots of different factors in their planning and design phase – not just the structural elements of the designs they build, but also how people will be affected by the design or how the environment will affect the design.

WHERE ARE BRIDGES BUILT?

In this activity, imagine you are a civil engineer trying to plan a crossing. Bridges are built to fit the environment around them. The specific bridge cannot be built anywhere else because bridges are individually designed to match the need in that one place and the specific challenges associated with that location. Challenge the learners to decide where to build a bridge for the specific environment (*Where should the bridge go?* handout).

Ask them to consider where people would most need a bridge, whether there are any environmental factors that might influence the location and whether there are any other issues that might make building a bridge difficult. They can use the *Bridge builder's checklist* handout to help consider all of the issues.





Once engineers have completed the initial design phases of their process, they then have to convert a plan to a three-dimensional object, whether it is a small-scale model or prototype device.

CAN YOU BUILD IT?

Using standard wooden building blocks (such as you might find in an Early Years setting), challenge learners to build the designs shown in silhouette only on the *Can you build it?* handout, using both the front and side elevation plans, to try to work out the bricks needed to create a self-supporting structure.



FRONT ELEVATION



SIDE ELEVATION

Discuss whether all the final block designs were the same for each group. Ask learners what they found the hardest part of this challenge? How do they think the process could be improved?

They might consider that having more information, such as the size, shape or number of bricks, would help speed up the build process, or that having clearer plans (not in silhouette) showing the exact nature of the designs would help to reduce the number of 'test' builds required to create the same overall design.

Challenge Time!



Challenge your learners to use the engineering design process with this activity.

Using the materials provided, learners must build a stable structure as tall as possible. The structure has to stand up in the breeze from an electric fan.

Using the *Design Challenge* handout, learners can work through the engineering design process to design and construct their towers. Each tower should be tested and then, if necessary, re-designed and re-tested.

The handout suggests using the Eiffel Tower as inspiration – the design does not have to be limited to only this idea, but might help steer learners in the right direction for completing stable structures.

The main purpose of the challenge is to incorporate the different stages of the engineering process – every group/learner should engage with identifying the problem, carrying out research, developing solutions, constructing and testing designs and finally communicating their ideas. To increase the challenge, a minimum height could be applied to the structures, or to develop other skills, a more detailed presentation about the design and structure testing process could be expected.

After all the designs have been tested and re-designed as necessary, ask learners to consider the main difficulties they faced during the process and how they overcame them? Did all groups have the same challenges? If the design basically worked the first time/test, were there ways to improve it? For example, could the stability be improved, or could fewer materials be used?

The iron triangle of engineering describes three factors engineers must think about when building a product or implementing a process. They must consider:

Time: how fast does the project have to be completed?

Quality: what features does the finished product have to include, and how good does it have to be?

Cost: how cheap or expensive is the whole project?

These three factors are related and affect each other. It is very unlikely that an engineering project is completed quickly, to a high quality and cheaply! Engineers will often have a number of different design options that meet their clients' needs – whether it is to complete the project quickly, to a small budget or to a very high quality.

Ask learners to consider how their project fits in with the iron triangle concept – did they do it quickly, could they produce it cheaper, or of a better quality? Would they have to adapt their design to make it faster to construct? Or if it needs to be higher quality?

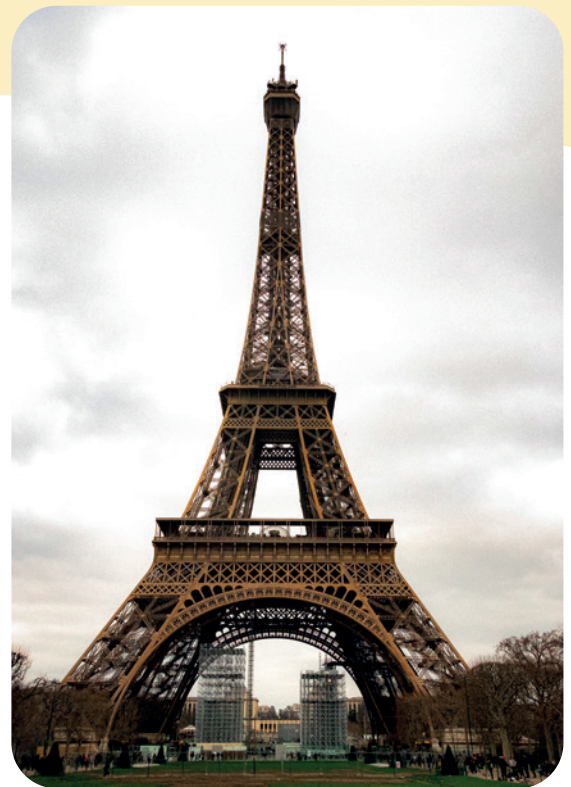
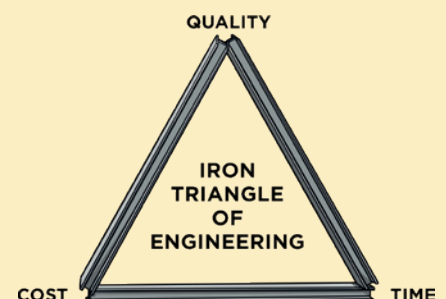


Photo by Sid Saxena on Unsplash



HOT TOPICS!

Research an engineer, for example, Archimedes, George Stephenson, Isambard Kingdom Brunel, Hedy Lamarr, George Carrythers, Roma Agrawal among others... To help you complete your research, use the *Standing on the shoulders of giants* resource. You could then complete a profile of your chosen engineer, to share their life and work with others.



Engineers try to find solutions to problems, and they often have to visualise a 2D image in three dimensions, or imagine a 3D shape as a two-dimensional diagram.

A geometry net is a two-dimensional shape that can be folded to form a three-dimensional shape or solid. You could try to match nets of different shapes to their 3D diagrams, or even build your own 3D shapes from geometry nets.



This links to building a template for concrete bars from nets in *Learning About Bridges Vol 1 Chapter Aiii: Materials – Cuboid net* handout.



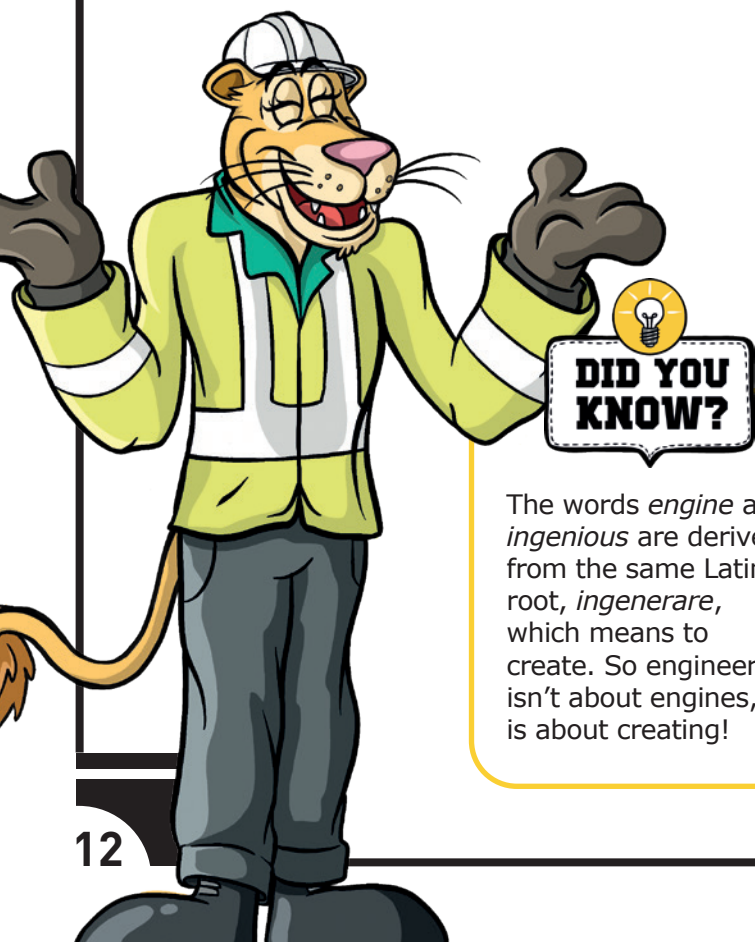
Photo by Sigmund on Unsplash

Have you ever built a house of cards?

Try to build the tallest tower of playing cards using just an ordinary pack of cards, propping them next to or on to each other.



Can you build a simple structure, like a den, to keep you warm and dry? When you design and test something like this, you are using the engineering process.



The words *engine* and *ingenious* are derived from the same Latin root, *ingenere*, which means to create. So engineering isn't about engines, it is about creating!



Langdon presents:

- *What do Civil Engineers do?* handout
- *Where should the bridge go?* handout
- *Bridge builder's checklist* handout
- *Can you build it?* activity sheet handout
- *Design Challenge* handout
- *Standing on the shoulders of giants* handout

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