Chapter F: Thinking like an Engineer. Different roles in Civil Engineering.

AIMS & OBJECTIVES

- To recognise the different engineering habits of mind
- To demonstrate the different core skills in learning and engineering
- To personally evaluate different engineering habits and skills

CONTEXT

There are lots of different engineering fields, and within these lots of different roles, with each role requiring a range of different habits and skills. However, many of these skills overlap as engineering habits of mind and are reflected in roles across the whole spectrum of engineering, and beyond.

Within civil engineering, there are designers, engineers, supervisors, construction workers, financial managers, surveyors to name but a few... Each role contributes to the success of the project. In short, people make bridges happen.

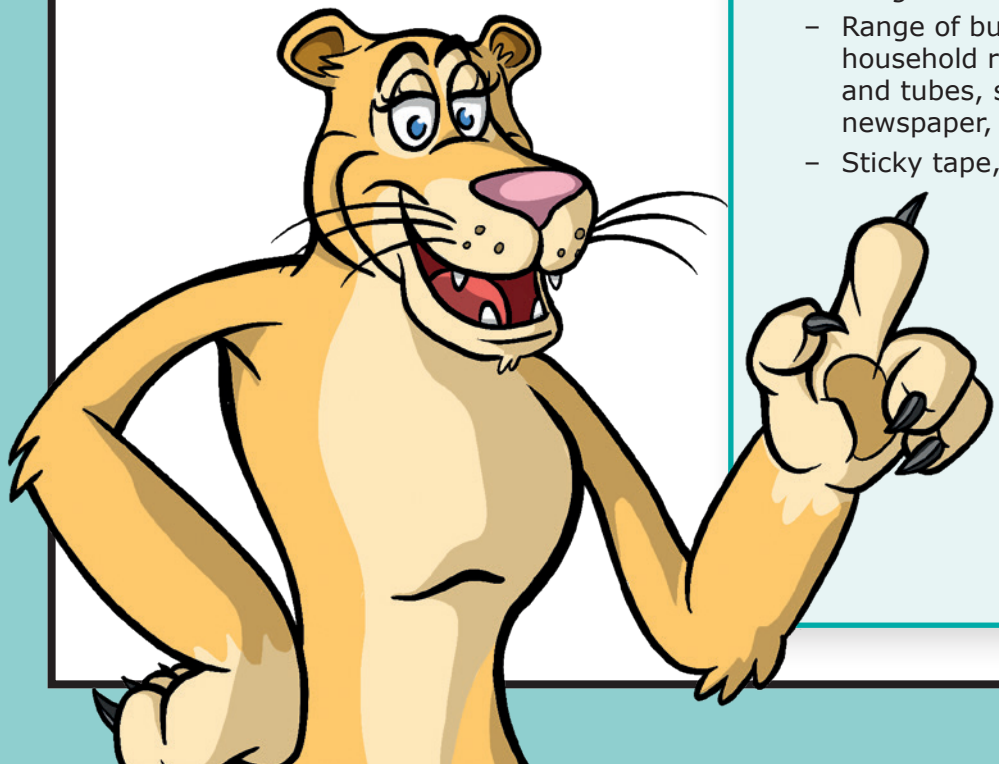
LANGUAGE OF BRIDGES:

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 habits of mind: a concept developed to characterise the range of skills usually found in those people that think like an engineer.

You will need...

- Cup pyramid teamwork challenge, per group:
  - 4-6 lengths of string/yarn
  - Rubber band
  - 6 large plastic cups
- Think like an engineer bridge building challenge, per group:
  - Handout: *Thinking like an engineer bridge challenge order form*
  - Range of building materials, such as household recycling, cardboard boxes and tubes, string, craft card, paper, newspaper, art straws
  - Sticky tape, washi tape, masking tape
  - Scissors/craft knife and cutting mat (as appropriate)
  - Glue/hot glue gun (as appropriate)
  - Ruler
  - Paperclips, treasury tags, bulldog clips (as available)
  - Mars bars, exercise books or masses for testing the bridges



Something to Try:

Meet the Future You is a careers quiz developed by EngineeringUK in partnership with UCL Engineering with the support of Tomorrow's Engineers Careers Working Group and takes learners through a series of questions designed to think about their skills and interests, to help identify the area of engineering they might enjoy working in. Aimed at 7-19 year-olds, it can be accessed through a web browser or is available as an app. It is based on profiles of real-life engineers and showcases a diverse range of engineers from different backgrounds. This could be used to inspire interest in engineering, and demonstrate that anyone can become an engineer.
https://mtfy.org.uk/

The Centre for Real-World Learning (at the University of Winchester) and the Royal Academy of Engineering have developed a series of Engineering Habits of Mind that are key skills found in those people that think like an engineer.

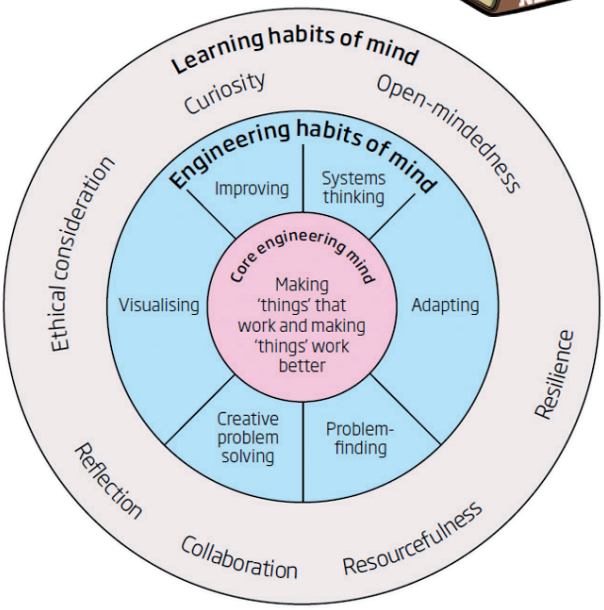
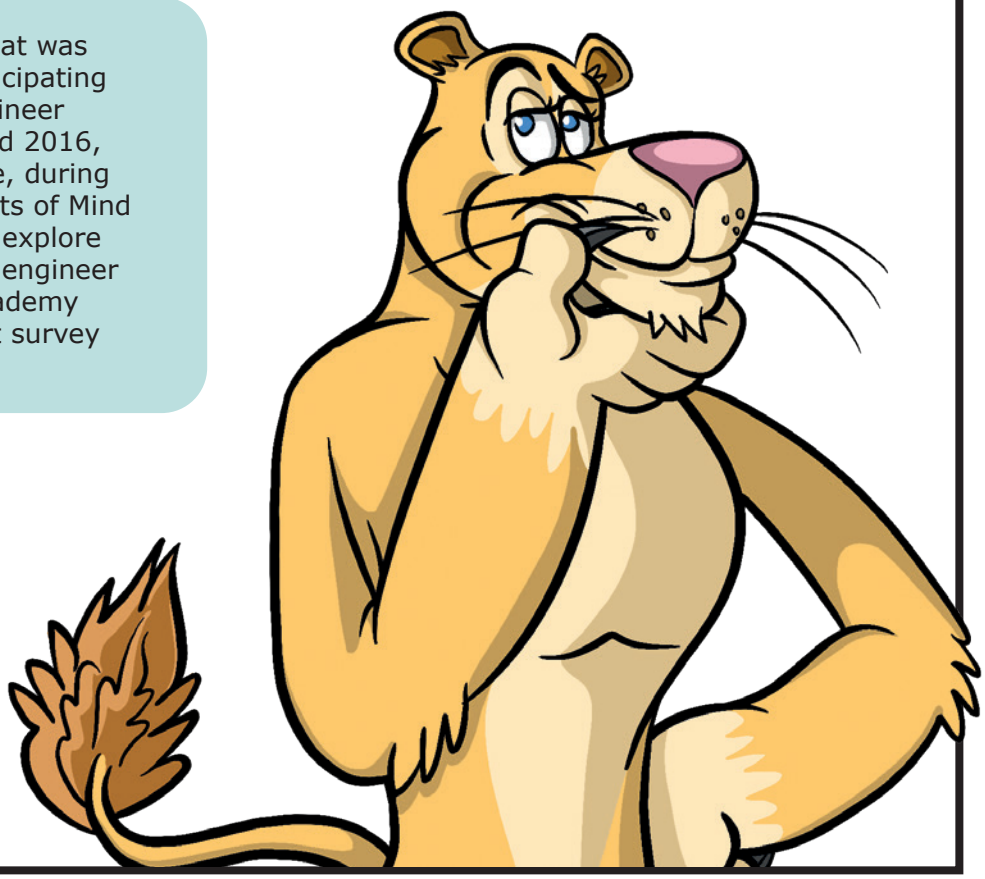


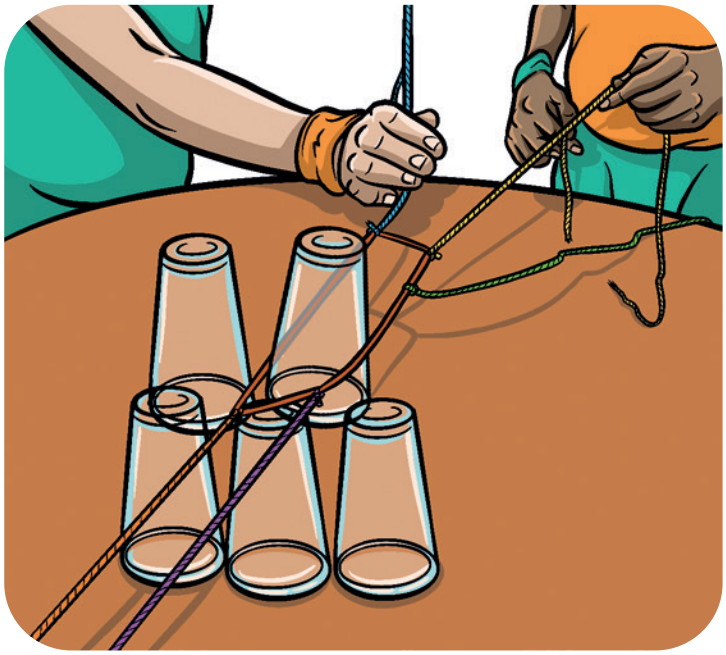
Image taken from Thinking like an engineer Implications for the education system – the May 2014 report for the Royal Academy of Engineering Standing Committee for Education and Training
https://www.raeng.org.uk/publications/reports/thinking-like-an-engineer-implications-full-report

There is a questionnaire that was developed for schools participating in the Thinking like an engineer research between 2014 and 2016, designed to be used before, during and after Engineering Habits of Mind intervention. Learners can explore whether they think like an engineer if you search for 'Royal Academy of Engineering EHOM short survey Winchester school'.



Teamwork is an essential skill in a variety of roles and careers, not least in engineers. Learners can develop their own teamworking skills by taking part in this activity.

Learners should be in groups of 4-6 people. The first challenge is to make a rubber band and string tool. This could be done in advance, to focus the activity more on developing teamwork, but making the tool can also be part of developing the engineering and scientific enquiry mindset.

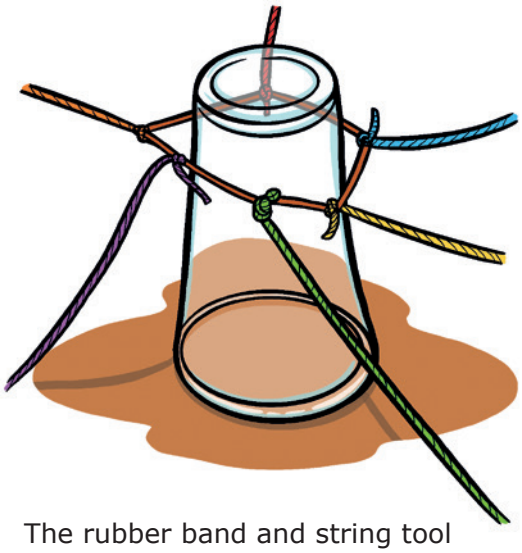


The object of the game is to construct a pyramid of all 6 cups in the shortest time possible.

To encourage learners to think like an engineer, ask them to reflect on the activity:

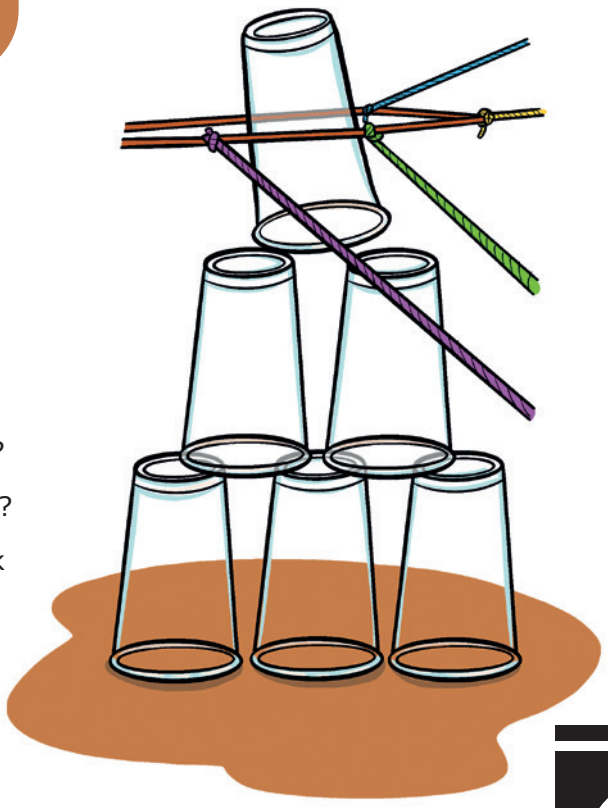
1. Was the challenge easy or hard?
2. What problems arose, and did you solve them?
3. How would you rate the teamwork in your group?
4. What were important skills used in this challenge?

To make the activity more challenging you could ask learners to complete the task without talking, or by blindfolding one (or more) of the group.

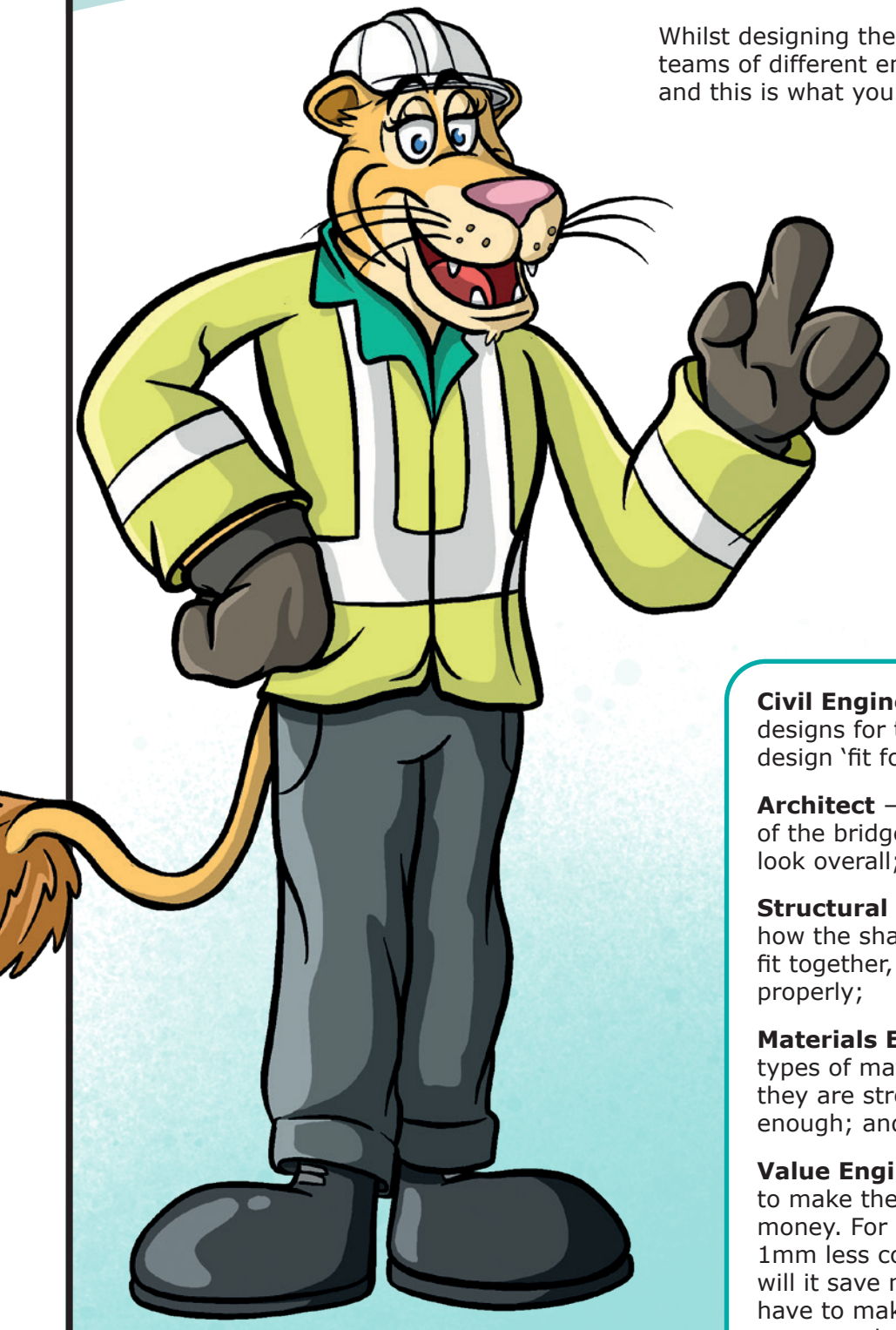


The rubber band and string tool is the only means of moving the plastic cups to build a pyramid of cups – nobody should touch the cups with any part of their body.

The tool is created by tying 4-6 lengths of string (depending on the number of participants in the group) to the rubber band. This can then be used to lift and place the plastic cups. The team must work together to adjust the tension in the string to allow the cups to be picked up and then deposited in the correct position.



Challenge Time!



Whilst designing these large one-off structures, teams of different engineers must work together and this is what you are going to be doing today.

But what does it mean to work in a team?

What different types of engineers might work together in a team to design something like an airport, bridge or rollercoaster?

What do you think each type of engineer does within the team?

Civil Engineers – choose the best designs for the job, they call this design 'fit for purpose';

Architect – considers the appearance of the bridge and how the design will look overall;

Structural Engineers – work out how the shapes of materials might fit together, to look right and join properly;

Materials Engineer – work out what types of materials to use and whether they are strong, flexible, rigid or soft enough; and

Value Engineer – work out how to make the design better value for money. For example, if builders use 1mm less concrete all over a structure, will it save money? But they also have to make sure if they use less concrete that the design is still safe, and fit for purpose.

In this challenge, learners will work together in teams to design and build a load-bearing bridge that spans a 40-cm gap and is entirely self-supporting. This can be based on junk modelling, using recycling, or using craft/construction materials, such as art straws, paper, card and so on. Part of the challenge is to set a budget for the design and construction of the bridge. For example, you could set a budget of £5,000 and construct a price list based on the materials to be used, such as £350 per sheet of paper, £750 per sheet of card, £50 per thin art/paper straw, £80 per thick art/paper straw, £200 per 50cm length of sticky tape, £15 per paperclip and so on (included in the resources is an order form for learners to use).

- Give the groups a short time (10 minutes) to discuss and plan how they are going to make their load-bearing bridge, including how they are going to spend their budget.
- The groups then have 30 minutes to build the strongest bridge they can. Do not give the learners any guidance at this stage; let them explore the possibilities for themselves.
- When the time is up, invite each team to bring their bridge to the testing zone. Load the bridges up with Mars Bars/exercise books/masses. When the bridge collapses, count the number of Mars Bars/exercise books/masses it was carrying just before it fell (i.e. do not count the last one).
- Record the scores for comparison. Ask the learners to observe the way the bridge failed: it is important that learners consider the weaknesses of their bridges. Encourage them to think of solutions to how they could be improved. Did it fold? At which part? What could be done to reinforce that point?
- After the learners' first attempts have been tested and discussed, give the teams the opportunity to improve their designs (15 minutes) by making modifications and test them again to see if they can better their scores. This is important as learning from experience is an important engineering process.

Learners can demonstrate their engineering habits of mind through creative problem-solving and collaborative teamwork, adapting their designs and being resourceful around using materials, and being resilient if the design doesn't work first time.

Just 4 Fun

Could you dress like a civil engineer on site, wearing PPE? Perhaps you could make a DIY civil engineer outfit for your soft toy or doll, to be part of your team?

HOT TOPICS!

Tinkering is a good way to introduce engineering concepts and habits of mind. There are lots of different resources available to encourage learners to tinker but a good introduction is the activity where learners try to help Rosie Revere from the book "Rosie Revere: Engineer" overcome her 'failure' to design a hat to keep the snakes off Uncle Fred's head. Learners can design and construct their own ideas using junk, and then communicate their ideas to the rest of the group at the end (all part of the engineering design process).

This can be found if you search for 'tinkering for learning snakes uncle Fred'.

You could design a plan for a local park or play area that would be easily accessible for everyone, and fun for children to enjoy. You could then present this to your class, group or family. This uses basic engineering principles in considering the problem, plan drawing skills and communication to explain how and why you have designed it the way you have.

DID YOU KNOW?

The first engineer is thought to be Imhotep, who designed the Step Pyramid at Ṣaqqārah, Egypt, probably about 2550BC.

Photo by Charles J. Sharp, CC BY-SA 3.0 via Wikimedia Commons

Langdon presents:

- *Thinking like an engineer bridge challenge order form* handout

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