The M in STEM? Practical use of STEM to teach Mathematical Problem Solving

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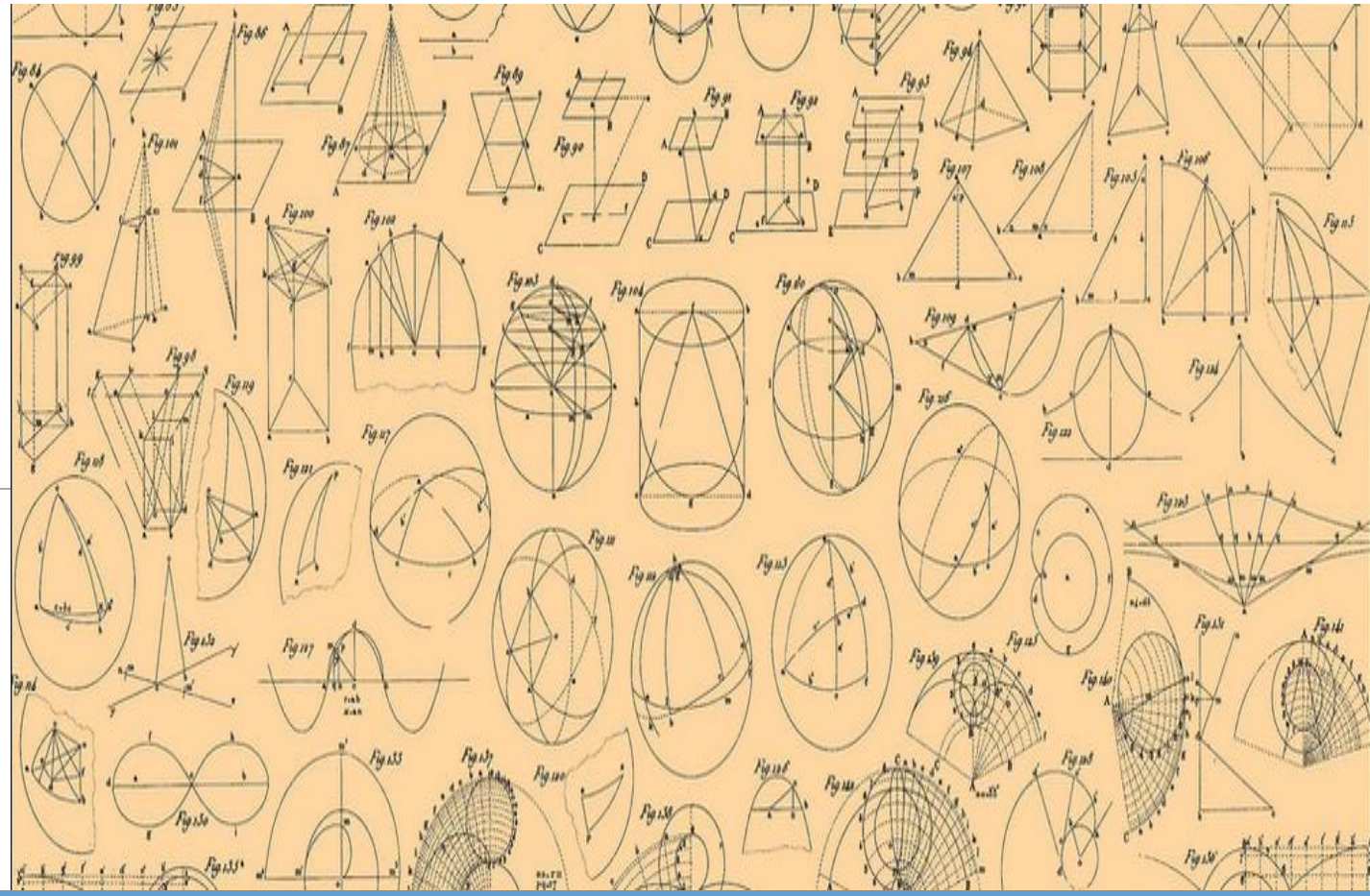
Shaping minds, shaping the world



Two key (and problematic) terms – STEM and mathematical problem solving

What is STEM/mathematical problem solving?

Is STEM (all 4 together) different from science, technology, engineering and maths as separate subjects?

Is mathematical problem solving different from problem solving?

Are they important?

Why are they important?

What is mathematical problem solving?

Problem solving is the ability of students to make choices, interpret, formulate, model and investigate problem situations, select and use technological functions and communicate solutions effectively. Students pose and solve problems when they:

- use mathematics to represent unfamiliar or meaningful situations
- design investigations and plan their approaches
- apply their existing strategies to seek solutions
- verify that their answers are reasonable (Victorian Curriculum).

Why does this change how we teach maths?

Students develop the ability to make choices, interpret, formulate, model and investigate problem situations, and communicate solutions effectively. Students formulate and solve problems when they use mathematics to represent unfamiliar or meaningful situations, when they design investigations and plan their approaches, when they apply their existing strategies to seek solutions, and when they verify that their answers are reasonable

Using maths in the workplace today

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Economic reasons to change the way we teach maths

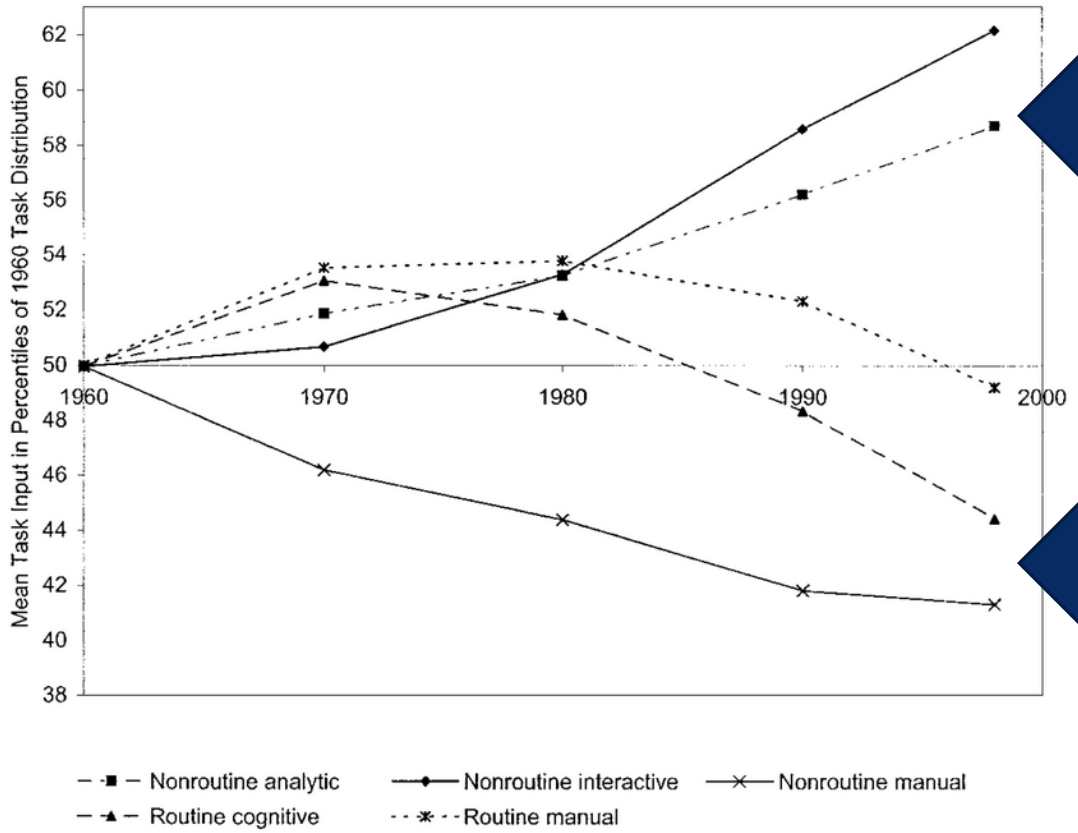


FIGURE I
Trends in Routine and Nonroutine Task Input, 1960 to 1998

Instead, the number of jobs that require ‘nonroutine’ thinking and complex communication skills rises

Computing, robotics and globalisation reduce the number of ‘routine’ and ‘manual’ workers needed

Autor, Levy & Murnane, 2003

Why STEM?

Some economists have shown that wages grow at a faster rate in cities that have higher levels of STEM workers (Peri, Shih, & Sparber, 2015).

When governments are trying to develop strategies for increasing prosperity, growth in STEM industries is argued to be key to increasing economic productivity.

Therefore, education policy is increasingly focused on STEM.

Why STEM – the girl who wanted to be a vet…

A grade 6 student (Eleni) told me that she wanted to be a vet one lunchtime.

I told her that this would tie into our next lesson about decimals beautifully.

She said, “I don’t want to be a vet anymore…”

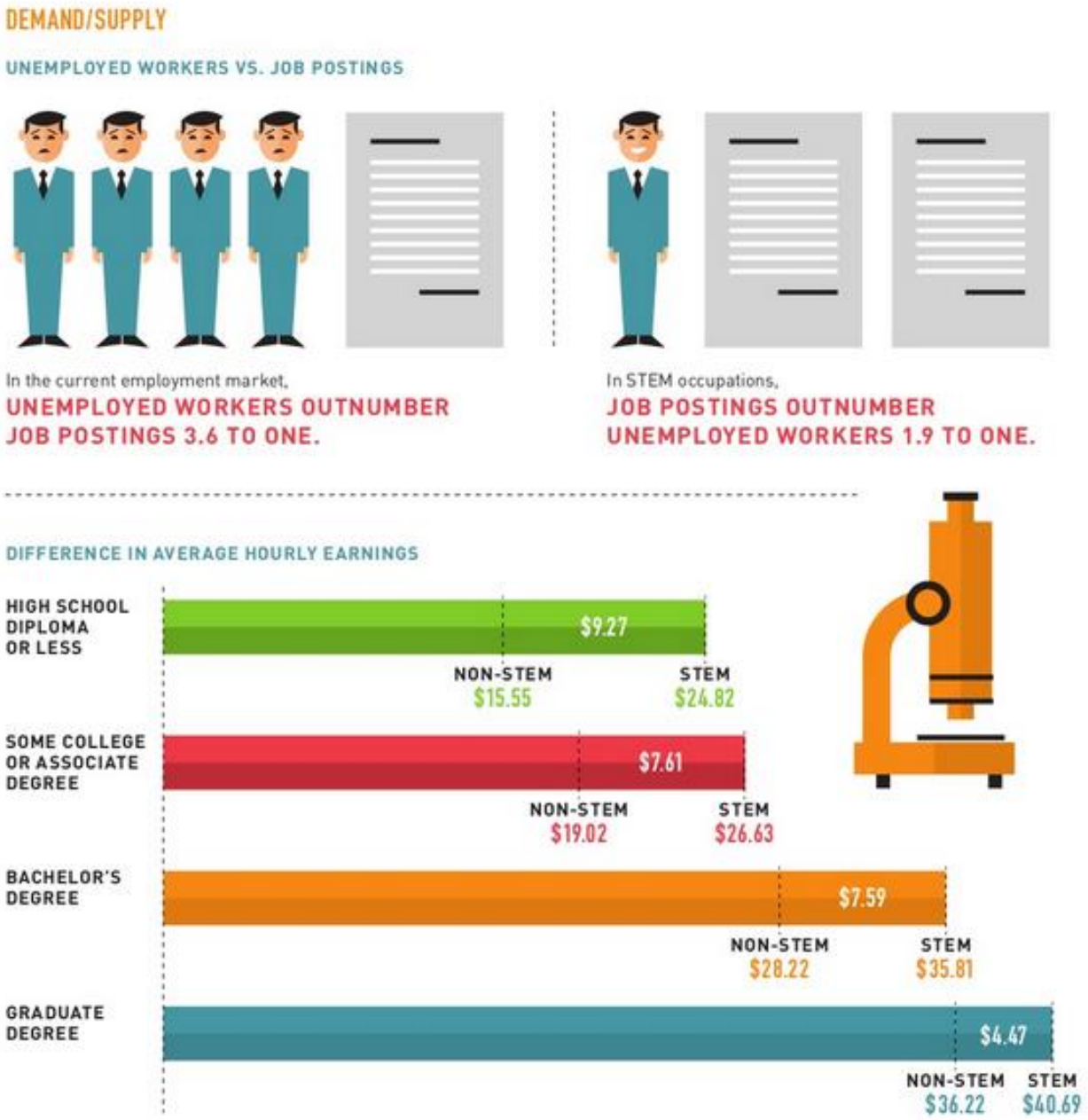
After 6 months of maths lessons focused on problem solving in STEM contexts she said:

“I don’t want you to think that I like maths or anything … but I get it. I can see why it’s useful. It’s not so scary”.

If you're able to use maths in STEM contexts…

According to current data, children who get maths are going to find it easier to find a job and will earn more money.

'Getting' maths does not mean the same thing that it meant 50 years ago – rather than 'algorithm solving', students need to engage in 'problem solving'.



Mathematical problem solving in STEM contexts

There are many studies about S & M

- Usually focus on measurement and data collection

Today, I'm going to focus more on TEM

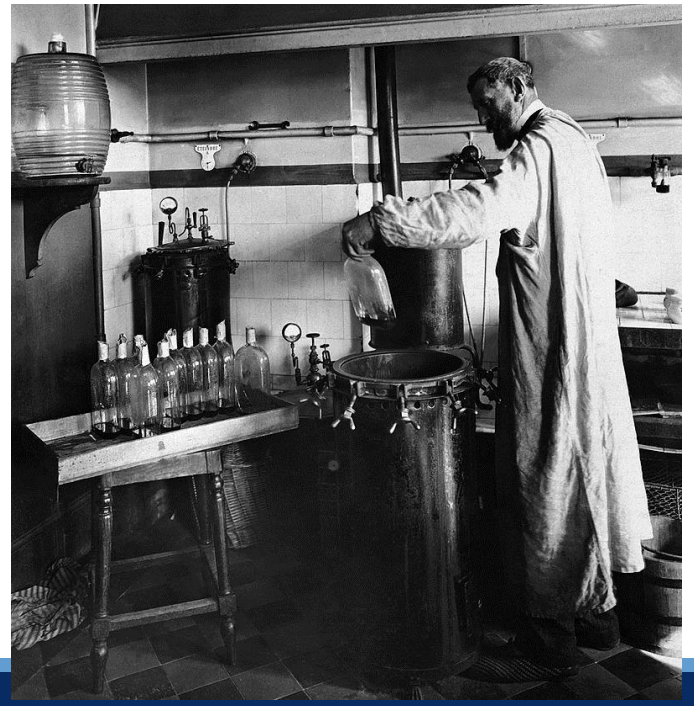
- What is engineering?

What is engineering?

"An **engineer** is a professional practitioner of engineering, concerned with applying scientific knowledge, mathematics, and ingenuity to develop solutions for technical, societal and commercial problems" (Wikipedia).

Think about pasteurisation:

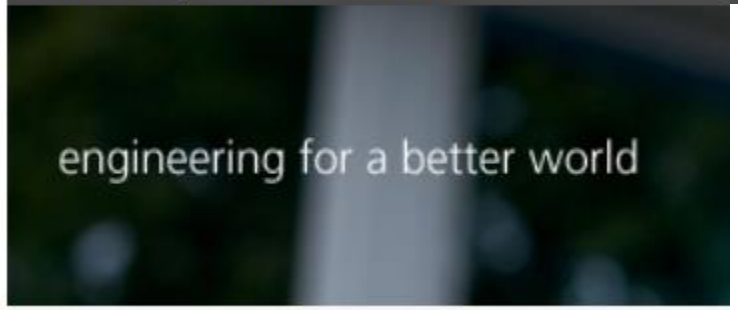
- Who 'discovered' it?



Engineering pasteurisation

GEA Liquid Processing

Core Competencies | Processes | Technologies | Units | Components | Service & Support | Brochure & Video | Company



Home > Technologies > Heat Treatment >

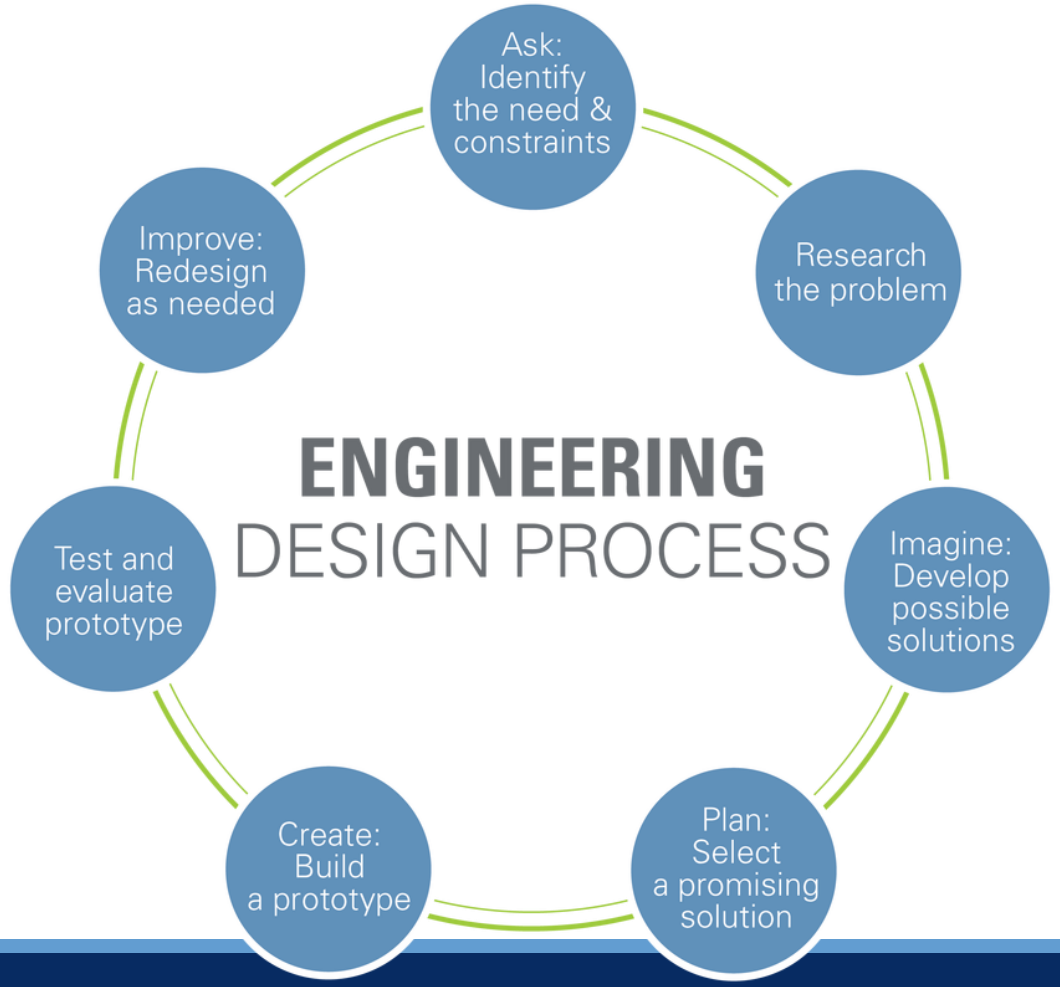
Low-temperature Pasteurisation

Compared to high-temperature pasteurisation , low-temperature pasteurisation is a process where a relatively low temperature (72°C) is used to kill harmful bacteria and at the same time achieve a product which is very similar to the raw product as regards taste and nutritional value.

Pasteurisation unit

During the low-temperature pasteurisation process, the product (e.g. milk) is pumped from a balance tank to a plate heat exchanger where it is heated to 72ºC for 15 seconds before being cooled to around 5ºC. The heating in the plate heat exchanger is achieved by means of hot water, while ice water or glycol are used to achieve the cooling effect.

Engineering and design process



While the Victorian curriculum focuses on forces and electronics when it describes engineering, many engineers work in areas where these are not the focus.

Instead, design process and a systematic approach to defining and solving problems is argued to be the key skill of engineering.

Engineering in the Victorian Curriculum

In the Design and Technologies curriculum, students create quality designed solutions across a range of technologies contexts. Students consider the economic, environmental and social impacts of technological change and how the choice and use of technologies may contribute to a sustainable future. Students also take into account the ethical, legal, aesthetic and functional factors that inform the design processes.

Through Design and Technologies, students plan and manage projects from conception to realisation. They apply design and systems thinking and design processes to investigate ideas, generate and refine ideas, plan and manage, produce and evaluate designed solutions. They develop a sense of pride, satisfaction and enjoyment from their ability to create innovative designed solutions.

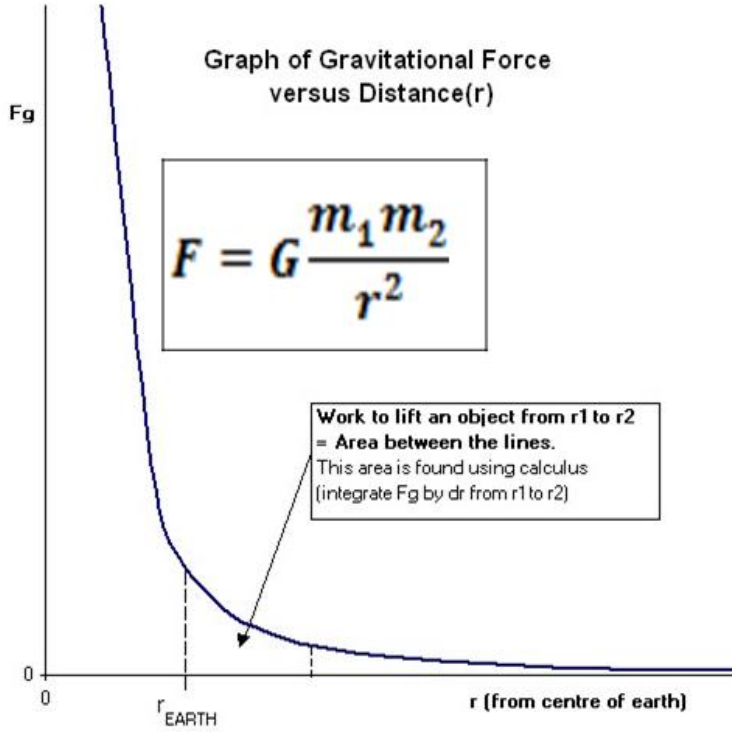
‘Whizz bang’ engineering tasks

I’m very lucky to get to work with engineering academics, developing engineering tasks for primary students.

They have great ideas for activities that help students learn about engineering and design process.

BUT the maths gets complex!

It gets too complex for primary school students to make there own mathematical models.



Start with the maths

If you want to use a design task to assess students' mathematical problem solving, you'll need a 'problem situation' that can be modelled with primary-school level maths

Preferably, you'll want to involve maths content areas that the students are familiar with, but need some more work on

I'm going to illustrate this approach with a very mundane example of a design problem that my Grade 5/6s and I worked on over a term

A design brief

"A **design brief** is a written document for a design project developed by a person or team (the 'designer' or 'design team') in consultation with the 'client'. They outline the deliverables and scope of the project including any products or works (function and aesthetics), timing and budget" (Wikipedia).

- Design requires problem solving with constraints
- Design process begins with defined criteria for success
- Working within these constraints towards success criteria creates problems…

Start with the maths; build the design problem

OnDemand test data of a grade 5/6 class showed that students were familiar with but made errors when:

- Modelling decimals
- Calculating addition and subtraction with decimals
- Expressing probability as ratios and percentages
- Converting metric units

What can we get children to design/engineer that will require the application of these mathematical skills?

Designing a problem

Identify student need → Design ‘problem’

There’ve been a number of serious accidents in the yard over the past year. School council has allocated $10,000 to making the school grounds safer. We need to develop a plan to fix the most dangerous part of the yard for under $10,000.

Identifying the most dangerous part of the yard

Working with the yard duty incident reports, I put together some messy data…

Date	Time	Incident	Students involved	Section of the yard	Sick bay	Hospital
12/6	1.15	Fall off a railing	1 x Grade 2	Peace garden	Y	Y
12/6	1.35	Collison	2 x Grade 3	Oval	Y	N
12/6	1.40	Fall of monkey bars	1 x prep	Prep playground	N	N

“Problem solving is the ability of students to make choices, interpret, formulate, model and investigate problem situations, select and use technological functions and communicate solutions effectively”

Assessing mathematical problem solving

Is there any evidence that the students are making interpretations, modelling, organising or making choices about how to approach the problem?

Student	Groups data		Makes a table		Works out group totals		Converts to percentages		Groupings include location		Other	
	NH	H	NH	H	NH	H	NH	H	NH	H	NH	H
Student 1												
Student 2												
Student 3												

NH (no help) and H (help)

If you give children difficult tasks without explaining how to solve the problem, you need to expect frustration

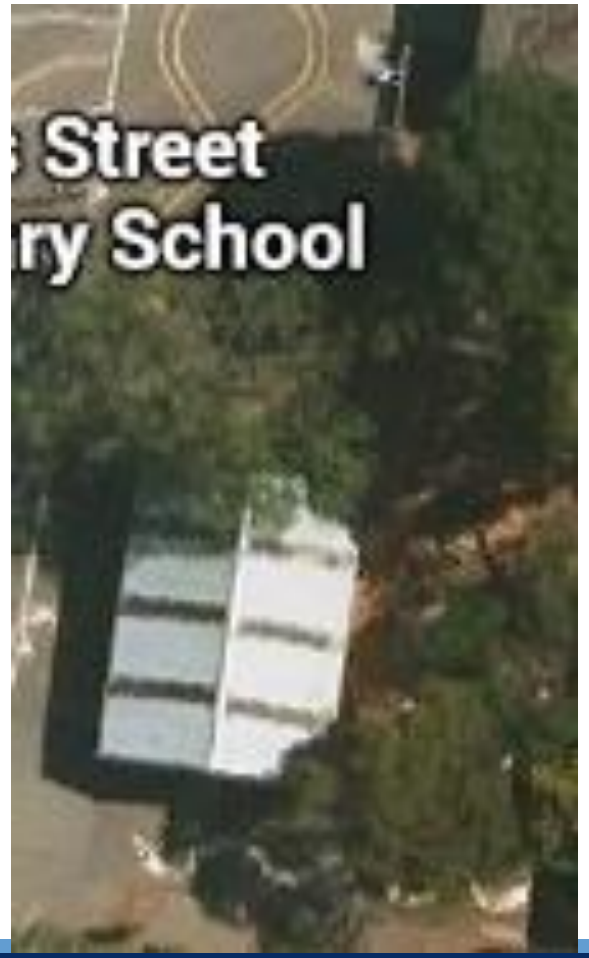
To avoid frustration from making the task quite unpleasant for the children, you'll need to limit the amount of 'struggle time'

About 15 minutes (or less) into the task, you're going to need to stop and usually get students to present about their approach to the problem

This will give those who are struggling some help

In terms of assessment, keeping track of who made a table before the class discussion can give you evidence about students' problem solving

Investigate the site



If we're going to use $10,000 to make the peace garden safe, what do we need to know about the peace garden?

In our initial attempt to measure this shed, some groups said it was 7m long, others said 12m long. Someone had to be wrong!

- This led to 3 lessons on measurement and retrying the activity the next week

Student	Appropriate units		Measures in a straight line		Strategy for partial units		Cuts out unnecessary measurements		Can break down the space into workable shapes		Other	
	NH	H	NH	H	NH	H	NH	H	NH	H	NH	H
Student 1												

What should we do next?

Students decided that we should make scale drawings so we didn't have to keep going outside

They suggested ways that we could make the area safer

I made up some figures for the cost of materials for each idea

The students then designed and costed their ideas and prepared a pitch for the principal

How did Eleni go?

While Eleni couldn’t model the problem before we had a class discussion early on in the project, later in the project (and in subsequent projects) she started to mathematise the problem straight away.

This also got me in trouble with other teachers…

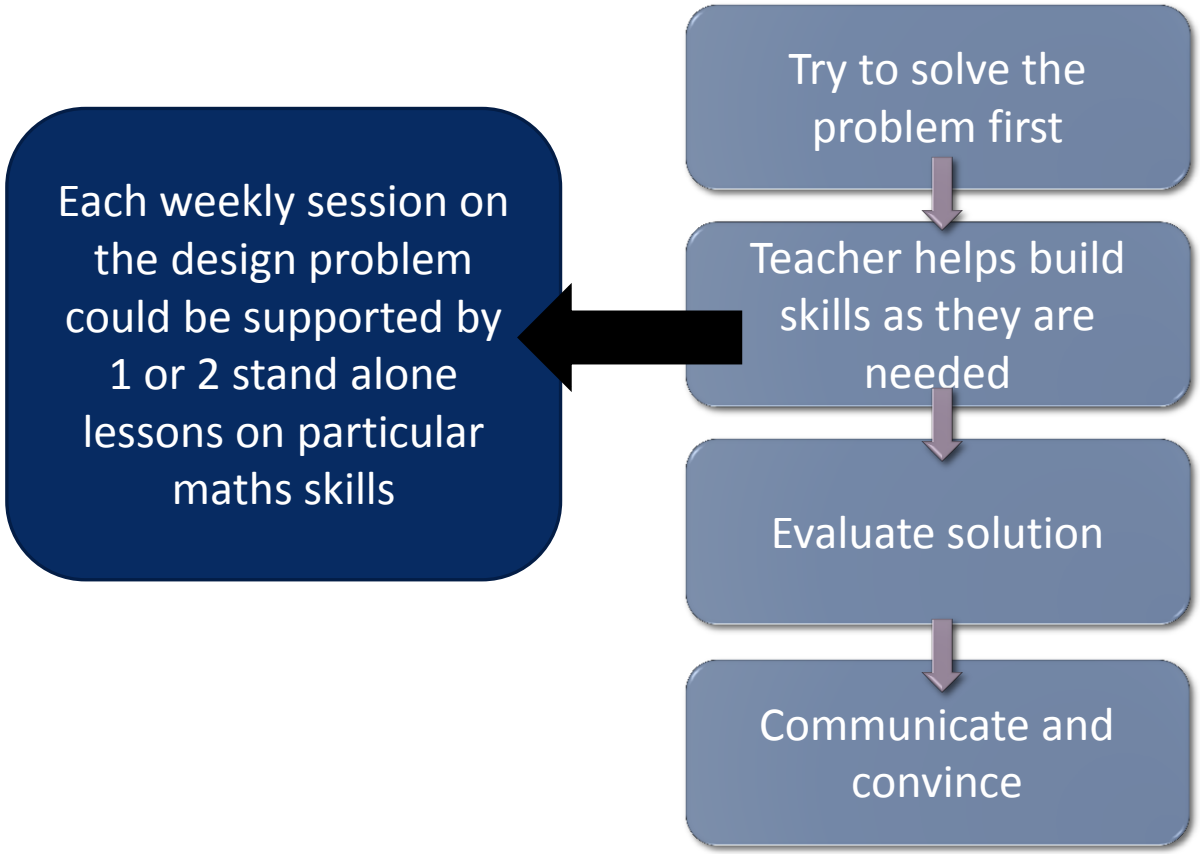
How did Evan go?

While Evan had never received anything except an A for maths for his whole life, he wasn’t very good at mathematising the problem situations.

This could then become a focus for his learning in mathematics.

This made him quite uncomfortable at first, but he started to get better at it, and I could track this development using my checklists and analysis of student work samples.

Design problems that support mathematical problem solving



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‘Project-based’ maths is hardly new…

Many maths teachers have been doing tasks similar to the one I’m presenting for years

- These kinds of tasks are often used as a fun side activity which don’t drive a maths program
- If you want to develop mathematical problem solving then these kinds of tasks can drive a term planner
- These kinds of tasks can also enable teachers to collect evidence about students’ approach to mathematical problem solving and design and technologies strands in the curriculum