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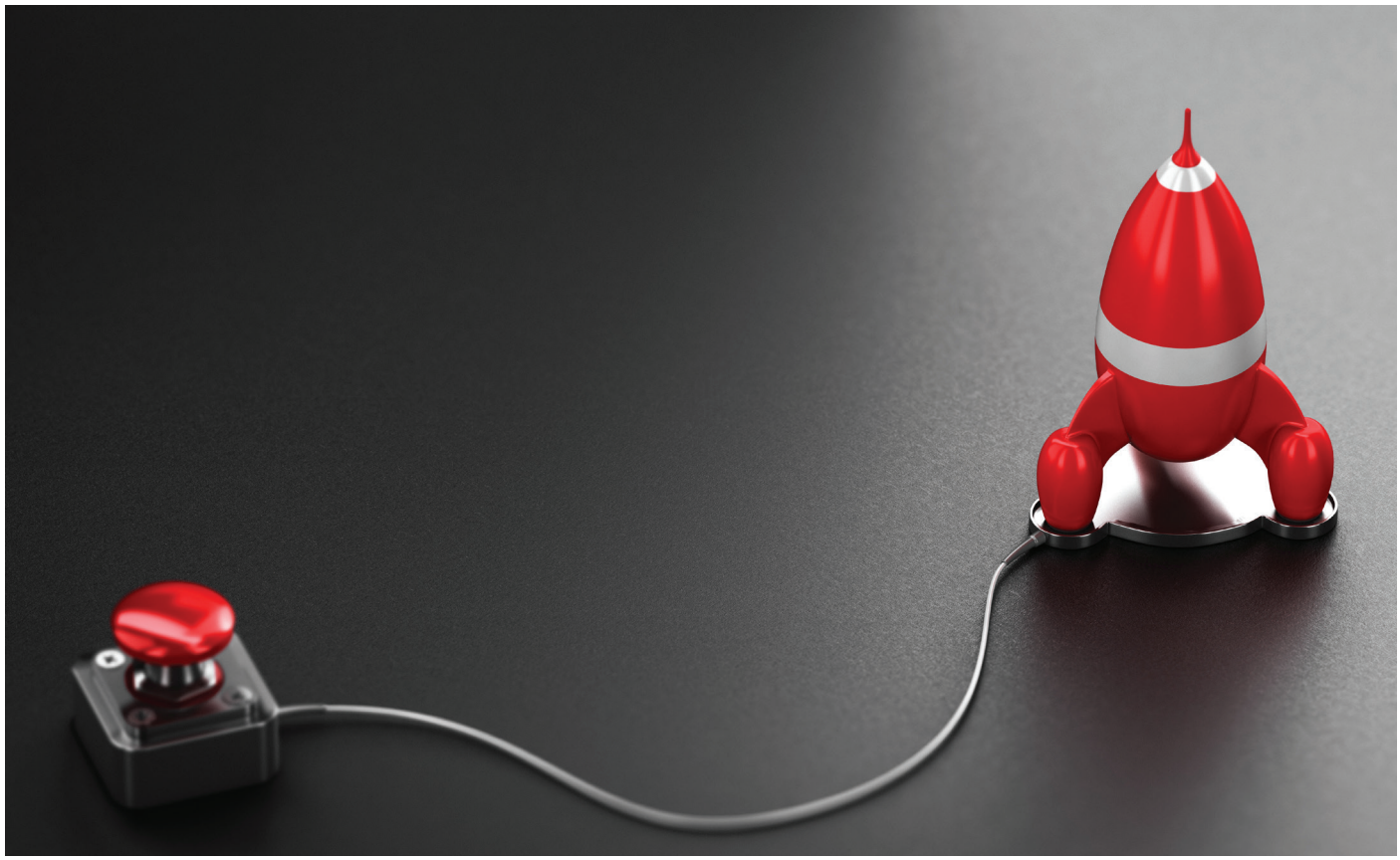
FEATURE

Power Up STEM Learning with Engineering

ENGINEERING IS A SUBSET of the design technologies curriculum. However too often in Queensland it is an overlooked element of the important science, technology, engineering and mathematics (STEM) agenda. Engineering happens when science and maths are applied to solve problems.

In classrooms engineering has great potential in learning as it is the 'glue' that connects and transforms STEM ideas into real-world applications. Students are offered the opportunity to solve problems from the world in which they live, build capabilities and increase self-efficacy due to methods of



continuous improvement and prototyping being 'baked into' engineering processes. It has the potential to inspire a 'whole-of-school-STEM approach' that promotes higher-order thinking, problem-solving and critical thinking.

Sheppard et al. (2009) suggest engineering education as inherently interactive and complex, saying, 'engineering has many publics', 'engineering incorporates many domains beyond the technical' and 'engineers affect the world'.

Misconceptions about engineering

Unfortunately, despite its importance, many Australian primary schools tend to put engineering in the 'too-hard basket'. This is perhaps because teachers assume it's being covered when they're running 'STEM' classes. However, they may inadvertently *silence* teaching and learning opportunities in engineering when they:

- Fail to describe the process as 'engineering' to students during a learning experience, for example when they ask students to build and test a bridge or create a spaghetti and marshmallow tower.
- Neglect to ask questions to prompt students to consider the basis for a problem or how a device works.
- Assume the goal is to create a finished working product every time.
- Minimise opportunities for teachers "to use their professional judgement and agency.

A recent Re-Engineering Australia (REA) report found most STEM school programs focus more on entertainment and struggle to meet the guiding principles of STEM teaching and learning (Myers, 2022). Central Queensland University specialist STEM educator, Dr Linda Pfeiffer, says schools that rely on after-school clubs are also missing the opportunity to truly embed STEM in the classroom.

Ben Harvey from Calamvale Community College says teachers often have the same misconceptions about engineering as they do about 'producing design solutions', which is part of the Prep to Year 10 Design Technologies syllabus. He says, 'People see these words and expect teachers and students will be required to develop a fully functioning product using a range of materials and possibly even digital components.'

'This just isn't the case. This misconception results in schools and teachers not wanting to go down the road of engineering as they feel they aren't qualified to teach it,' says Harvey, who's the college's Head of Program for Innovation, Technology and Interactive Learning. He's seen first-hand the 'lack of understanding around what's required for students to produce a designed solution'.

Why the primary years matter for both genders

Despite these misconceptions, early engagement in engineering at primary schools delivers benefits across the years for all students, including for learners' future careers. According to Engineers Australia, most students express interest in everyday occupations as early as Year 4 (Romanis, 2018). Fast forward to the engineering profession though, and just 13% of engineers are women.

The REA report (Myers, 2022) encourages schools to target the genders differently with their STEM programs. 'We found that boys' motivation rises with continuous human interaction, particularly with role models and mentors. Boys appear to learn by apprenticeship and respond directly to the people they meet and interact with. … The movement of boys into careers will increase when we can facilitate an increasing interaction between students and adults in industry roles,' the report says.

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'Girls, on the other hand, respond to managing complexity in environments. Highlighting the processes and complexity involved in career pathways will attract them and lift their motivation to become involved. Girls react positively to the project management aspects of careers … This research has shown that correctly targeted interventions can dramatically change the number of girls interested in specific career pathways.'

Engineers Australia has been upskilling teachers and supporting in-school programs in engineering disciplines as part of its National STEM Strategy 'Create Tomorrow's Engineers' (Romanis, 2018). In June, Engineers Australia was quoted in *The Australian* newspaper as saying it would 'parachute retired engineers into classrooms to teach hands-on maths and science'.

The article also quoted Professor Lisa Harvey Smith, the Australian Women in STEM ambassador, saying in many parts of the globe, engineering was a 'natural career

path' for women and that 'It makes no sense to ignore 51% of our population in the design and construction of our infrastructure and technologies.'

Bringing engineering to life in class

So how can engineering add dynamism to STEM teaching and learning? There are many examples, but at Calamvale Community College, Harvey says Prep students tackle a unit 'How the World Works' in Term 3. They complete an inquiry into the properties and purposes of materials, and design solutions to suit a specific problem.

'This will see students design a solution to allow a gingerbread person to "travel" across the water without getting wet.' Teachers and students don't need to source materials such as metals or hard plastics, instead they prototype with cardboard or recycle and use old bottles. Year 6 students undertake an inquiry into the use of science, engineering and design, to create a prototype to help with the impacts of a natural disaster.

In addition, Calamvale Community College also uses LEGO® for STEM teaching up to Year 9 through a specialist STEM education consultancy that runs school incursions. These programs focus on STEM skills and depending on the stage of development of students include theoretical concepts, practical applications of theory, critical thinking, problem-solving, data analysis, engineering, physics and coding.

The school is also open to new ideas and was inspired to take up the concept of 'rapid ideation' introduced by a new teaching staff member. Students work in groups of three or four to solve a unique problem using a bag of limited resources. 'This activity gets students into the mindset of designing solutions to a problem and prototyping – usually engineering – to address it,' says Harvey.

Design Technologies students at Calamvale Community College practice 'rapid ideation' in the second week of every term to keep their mindsets open to engineering. Meanwhile, students in STEM classes create a 'prototype of a robotic hand' using only string and cardboard, not robotics.

Spotlight on a signature pedagogy

Each learning area has its core practices for teaching, that is, signature pedagogies. Shulman (2015) described these as having three structures: surface, deep and implicit. Each structure details the concrete acts of teaching and learning, as well as the assumptions about *how* to teach, plus the underpinning professional attitudes, dispositions, and beliefs.

Here's how they work from an Australian perspective. STEM education expert, Associate Professor Linda Hobbs, from Deakin University's School of Education told *EducationHQ* that signature pedagogies are 'really at the core of inducting your students into a way of thinking, doing and being when they learn different subjects, [asking] what goes with the subject and what's required to teach it?' For example, mathematics draws on mostly explicit instruction and a linear progression through the content, history centres on contesting perspectives about events, while science embraces inquiry learning.

So how can your teachers harness a signature pedagogical approach to unlock teaching and learning in engineering? Tingerthal (2017) has helped to pinpoint the signature pedagogy of engineering education:

- Demonstrate using physical and virtual models.
- Build in problem-based learning.
- Harness active learning approaches, including a hands-on 'lab' approach.
- Offer extra learning opportunities such as guided instruction, online resources and enhanced notes to extend beyond a textbook.
- Use technology to blend or flip learning.
- Embrace 'authentic environments' that are experiential, interdisciplinary, collaborative, inquiry-based, and challenging.

Engineering and its signature pedagogies have a key role in the teaching of STEM in all classrooms across Queensland. Celebrating engineering as part of STEM learning means embracing inquiry, student-centred, authentic situated, and problem-based learning.

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