Working with teachers on STEM projects

An engineers guide

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Introduction

Engineers are often asked to participate with teachers on STEM projects. Engagement of engineers to work with teachers can arise through a number of mechanisms.

For example, the organisation where the engineers work might choose to reach out to participate in the various STEM programs. These can be run through schools or other organisation, personal interactions with teacher and with the local community. Engineers Australia is sometimes approached to find volunteers to participate in STEM projects or through Government funded programs such as the STEM Professionals program managed by the CSIRO to connect engineers to partner with teachers.

You can find more information on the CSIRO STEM Professionals program on the CSIRO website.

Members have identified several scenarios where they have been asked to work with teachers in schools. These scenarios generally fall into the following:

- Presentations to students on what engineers do within a pre-existing framework or project
- Working with teachers to design engineering projects
- Judging engineering project competitions.

Scope of guidance

The guidance set out in these guidelines focuses primarily on establishing and maintaining sound relationships with teachers for each of the above endeavours.

There is also an important focus on ensuring clear, consistent language and definitions to support educational outcomes. These guidelines are intended to build on the document engineering and the *Australian Curriculum F to Year 10 and Senior Secondary*.

In this context engineering projects may vary from single lesson in class through to multi lesson more in-depth projects.

Structure

These guidelines have been structured as follows.

Part 1: Working with vulnerable people

Part 2: Partnering with teachers

Part 3: Engineering projects for each of the scenarios at the different stages of education

- Primary school Foundation to year 6
- Secondary Years 7 and 8
- Secondary Years 9 and 10
- Senior secondary Years 11 and 12 and

Part 4: Pathways to an engineering career

What engineers do

Engineers create technology solutions to solve problems using mathematics and science to understand the problem, design and improve the solution.

In simple terms engineers:

ASK
Understand the problem, identify constraints, and technologies available to solve the problem

IMAGINE
Identify possible solutions, estimate solution effectiveness

PLAN
Identify how will the solution be implemented, identify technologies and processes to be used

CREATE
Build the solution and test it

IMPROVE
Evaluate test results identify areas for improvement, implement improvements

E in STEM
is often described as an integrative function between science, mathematics and technologies where engineers use a range of skills and knowledge to solve real world problems.

Technology
refers to methods, systems, and devices which are the result of scientific knowledge being used for practical purposes. **Science** is the body of knowledge that explores the physical and natural world. **Mathematics** is the study of numbers, shapes, and patterns.

Engineering
is the application of knowledge in order to design, build and maintain a product or a process that solves a problem and fulfills a need (i.e., a technology). An important aspect of engineering is understanding the properties of the materials used to create technologies. By understanding the properties of materials engineers select the most suitable material for the technology they are creating to solve an identified problem.

Engineers
use **mathematica**l and **scientific** understanding to analyse a problem, describe it, talk about it, and successfully find and execute a **technology** solution. In the various engineering fields, different mathematical techniques may be applied to analyse and design a specific solution. For example, linear algebra is widely applied in electrical engineering to design electrical circuits. In civil and mechanical engineering, geometry is used to design structures and ensure that they perform in a safe and meaningful way. Industrial engineers use calculus to find the rate at which certain variables will change in a given operation.

Part 1: Working with vulnerable people

Engineers working with teachers and children in schools need to be aware of the requirements related to protecting the safety and interests of students involved with the projects.

Although the legislation in each state and territory is different all states and territories and the federal government have agreed a set of National Principles for assuring the safety of children. These principles are set out below.

National Principles for child safe organisations

1. Child safety and wellbeing is embedded in organisational leadership, governance, and culture.
2. Children and young people are informed about their rights, participate in decisions affecting them and are taken seriously.
3. Families and communities are informed and involved in promoting child safety and wellbeing.
4. Equity is upheld and diverse needs respected in policy and practice.
5. People working with children and young people are suitable and supported to reflect child safety and wellbeing values in practice.
6. Processes to respond to complaints and concerns are child focused.
7. Staff and volunteers are equipped with the knowledge, skills, and awareness to keep children and young people safe through ongoing education and training.
8. Physical and online environments promote safety and wellbeing while minimising the opportunity for children and young people to be harmed.
9. Implementation of the national child safe principles is regularly reviewed and improved.
10. Policies and procedures document how the organisation is safe for children and young people.

Further information on the National Principles can be found on the Child Safe website.

As part of the initial engagement with the teacher, engineers should seek advice as to whether the nature or duration of the project will require a background check to confirm their suitability to work with vulnerable people. Additional information on the processes applying in each state and territory can be found through the links in the table below. Note that in many jurisdictions, checks for volunteer categories are free.

State		
Australian Capital Territory	Working with vulnerable people registration	Access Canberra
New South Wales	Working with children check	NSW Office of the Children's Guardian
Northern Territory	Ochre card	SAFE NT
Queensland	Blue card	Queensland Government
South Australia	Working with children check	Department of Human Services
Tasmania	Registration to work with vulnerable people	Tasmanian Government
Victoria	Working with children check	Working With Children Check Victoria
Western Australia	Working with children check	Government of Western Australia

Advice should also be sought from the teacher on any other school policies that will need to be complied with as part of their participation in the project.

Additional guidance can be obtained through the STEM Professionals in Schools Program managed by the CSIRO.

Part 2: Partnering with teachers

When engineers work with teachers on engineering projects the establishment of an effective partnership with the teacher(s) and the school which is respectful, and trusting is paramount.

These guidelines set out key principles and steps to be considered in order to establish these relationships.

In the process of establishing the respective roles of engineers and teachers it is important to keep in mind that engineers would normally be engaged to provide insights into engineering and its application in the community while teachers bring expertise in setting learning objectives and determining the learning and assessment approaches.

Take time to get to know the teacher, key school policies, the challenges faced by students and objectives of the project.

Communicate frequently to identify issues and problems and continually build the relationship. Build common ground. Use formal and informal methods to convey ideas and document agreements.

Avoid the use of technical terms that may cause confusion. Try to use terms and vocabulary used by teachers and educators with their students.

Recognise and respect the professional competence of the teacher. Openly acknowledge and respect the value and importance of the resources, perspectives, knowledge, and time each party devotes to the partnership. Build mutual respect.

Use feedback from all parties involved to inform project refinement, and continually build the relationship.

Jointly develop ground rules for how decisions will be made, how problems will be addressed, how grievances will be handled.

Stay Flexible. Do not expect everything to go exactly as planned. Stress that unexpected results, errors, and malfunctions are a normal part of the engineering process and can result in positive learning outcomes.

Prepare to discuss your engineering experience and explain it in ways that are relevant to the level of students that you are working with. Engage with the teacher on the likely understanding that students may have with engineering and the various fields of engineering.

Familiarise yourself with what engineers do in fields of engineering practice outside your own field of practice. Think about how you might relate to student's real-world experience of other fields of engineering practice. The teacher will help you in understanding the student's likely exposure, knowledge and experiences of problems and issues in their community or issues that they have been discussing in classes or are likely to be familiar with.

Recognise that many young people have strong visual and kinesthetic (hands on) learning preferences, some may be less attuned to auditory or reading learning. Consider the use of models, videos, online resources, metaphors, simulations, experiments to illustrate key concepts.

Reinforce the fun elements with both teachers and students.

Clarify roles and responsibilities and establish a shared understanding of who will be responsible for what.

Typical roles that engineers might undertake include:

- presenting a real-world problem for students to solve
- mentoring students through the design thinking or engineering process as they work to produce solutions to problems
- suggesting references and online resources that students can use
- demonstrating real-world skills, techniques, and processes that students can apply to their project work
- providing feedback for students on their solutions
- providing advice on engineering careers and the relevance of STEM learning to engineering
- being an aspirational role model for the engineering profession
- providing real world insights into the role of engineers in the community, to improve knowledge and understanding of engineering
- explaining how engineers consider technology options and how they use science knowledge and enquiry skills and mathematics to understand the scope of the problem and assess the feasibility of identified options

Typical roles that teachers undertake include:

- identifying student learning needs
- advising on how the engineering project relates to the curriculum
- deciding on the teaching method to be used
- advising on desired learning outcomes and assessment criteria
- advising on and managing student access to required materials and resources
- advising on relevant school policies
- facilitating relationships with other members of the school and the community

Part 3: Engineering projects at the different stages of education

Engineering presentations to students

Engineers Australia has published a tool kit for engineers to present to primary school students.

The toolkits which provide a range of slides and notes have been designed for engineers to tailor to discuss engineering based on their own experiences and insights.

These guidelines provide additional information for engineers working with teachers to ensure that the material they are presenting, and their approach is consistent with the learning objectives being pursued by the teacher and the school. Therefore, these guidelines focus on establishing and maintaining relationships with teachers undertaking engineering and related projects.

When working with teachers to undertake these presentations the following issues should be discussed with the teacher ahead of tailoring the presentation.

What is the best approach to engage with the teacher and school, to build and maintain relationships?
Is there a whole-school focus that the school community is currently concerned with?
What engages the students? What are the students' ideas and interests?
How will the general capabilities (literacy, numeracy, ICT, critical and creative thinking, personal and social capability, ethics, and intercultural understanding) be addressed?
How will science, mathematics and technologies be addressed?
What have students learned in previous years? What can they do?
What resources are available to be used by the students?
What ideas, interests, and areas of expertise does the teacher want to have conveyed?
What information about engineering and practical examples would be of interest to the students?

Designing engineering projects

When engineers have agreed to assist the teacher design an engineering project it is important to understand that not all learning areas of the curriculum will necessarily need to be addressed but rather should focus on those areas identified by the teacher. Equally, not all engineering issues will always need to be addressed in order to design an engineering project that meets the intended learning outcomes.

The following issues should be addressed with the teacher to establish the context for the engineering project:

What is the best approach to engage with the teacher and school, to build and maintain relationships?
Is there a whole-school focus that the school community is currently concerned with?
What engages the students? What are the students' ideas and interests?
What is the desired duration of the project? For example, single lesson; multiple lessons; in classroom or extra curricula. Over a term or several terms.
What access might students have to expertise, mentoring or coaching?
What is the planned role of the teacher? Is there a role for parents and carers or the community?
What have students learned in previous years? What can they do? What are the key areas that the teacher wants to build on?
What resources are available to be used by the students?
What is the risk appetite of the school?
What learning outcomes are intended to be achieved – general capabilities?
What learning outcomes are intended to be achieved – mathematics? For example, number and place value, fractions and decimals, real numbers, money and financial mathematics, patterns and algebra, linear and non-linear relationships, using units of measurement, shape, location and transformation, geometric reasoning, pythagoras and trigonometry, chance, data representation and interpretation.

What learning outcomes are intended to be achieved – science? For example, biological sciences, chemical sciences, earth and space sciences, physical sciences, nature, and development of science, use and influence of science, questioning and predicting, planning, and conducting, processing, and analysing data, evaluating, communicating.
What learning outcomes are intended to be achieved – technology? For example, technologies and society, technologies contexts, engineering principles and systems, food and fibre production, food specialisations, materials and technologies, specialisation, investigating and defining, generating and designing, producing and implementing, evaluating, collaborating and managing, digital systems, representation of data, collecting, managing and organising data, investigating and defining, generating and designing, producing and implementing, evaluating, collaborating and managing.
What technology options are the students expected to explore, including those technologies which are not necessarily available or mature?
Will students be encouraged to explore digital solutions or utilise digital technologies in their approach to the design process, for example, to understand the problem, communicate insights and improve solutions.
What are students expected to do?
How will the intended learning outcomes be assessed?
How will you derive positive learning outcomes from (inevitable) errors, mistakes, malfunctions, unexpected results?
What ideas, interests, and areas of expertise does the teacher want to convey?
How will the project progress be tracked (prior to getting the final deliverables)?
Are there any projects that have already been developed that meet the needs?
How will the project objectives, structure, assessment criteria be documented? Who is responsible for approving the project for delivery to students?
How will the effectiveness of the project to deliver learning outcomes be measured and improved?

Primary school

When working with a teacher to design an engineering project engineers should keep in mind the typical progression of students and intended linkages to the curriculum planned by the teacher. This is to ensure that expectations for the complexity to issues and problems being explored through the project are appropriately targeted to the student cohort. While engineering projects provide the opportunity for students to learn across many topics and gain a broad range of skills, not all learning areas or general capabilities will necessarily need to be covered. It should be expected that the teacher will want to focus on particular elements to enable a quality learning experience for students.

For primary school level these guidelines have been organised to cover progression from Foundation, levels 1 and 2, levels 3 and 4, and levels 5 and 6. For each of these levels the guidelines have included typical learning outcomes expected for each of these levels. Please note that these learning outcomes are indicative only and are provided to assist engineers to understand the learning outcomes that are likely to be pursued through the engineering project. The teacher is the person best positioned to advise on the intended learning outcomes as the teacher will understand the capabilities of students and how the project is intended to fit with the planned syllabus.

Foundation

Typically, at completion of the Foundation year students will be able to:

- communicate with others in familiar situations, create their own texts such as giving information orally or in writing, presenting a narrative, which may include pictures.
- connect numbers and quantities up to 20, count numbers in sequences up to 20, continue patterns and compare lengths of objects, use materials to model problems, sort objects and discuss answers, group and sort shapes and objects.
- explore the needs of living things, investigate the properties of everyday materials explore changes in our world, explore how things move, experiment with interactions between materials and devices and people.
- design and create solutions to challenges through guided play and by safely using materials and equipment, work safely online, represent data as pictures, symbols and diagrams, and sequence steps to solve simple problems.

Years 1 and 2

Typically, at the completion of year 2 students will be able to:

- add pictures to what they write produce their texts using computers or other devices, listen and give talks to the class about a topic.
- describe number sequences and locate numbers on a number line, represent simple fractions using pictures, describe and draw shapes and objects, and use units to measure length, describe the outcome of a chance event, collect, and investigate data collected from simple problems.
- learn about living things and the environment, look for patterns that occur in life cycles of living things, explore how they can change or combine everyday materials, examine how light and sound are produced, investigate simple systems.
- design and safely make a product, for example, create a musical instrument using recycled materials, represent data as pictures, symbols, and diagrams, break down a problem into parts and sequence the steps in finding a solution.
- students explore and investigate technologies – materials, systems, components, tools, and equipment – including their purpose and how they meet personal and social needs within local settings. Students develop an understanding of how society and environmental sustainability factors influence design and technologies decisions. They evaluate designed solutions using questions such as 'How does it work?', 'What purpose does it meet?', ' Who will use it?', 'What do I like about it?' or 'How can it be improved?' They begin to consider the impact of their decisions and of technologies on others and the environment including in relation to preferred futures. They reflect on their participation in a design process. This involves students developing new perspectives and engaging in different forms of evaluating and critiquing products, services and environments based on personal preferences.
- using a range of technologies including a variety of graphical representation techniques to communicate, students draw, measure, model, and explain design ideas; label drawings; draw objects as two-dimensional images from different views; draw products and simple environments and verbalise design ideas.
- they plan (with teacher support) simple steps and follow directions to complete their own or group design ideas or projects and manage their own role within team projects. Students are aware of others around them and the need to work safely and collaboratively when making designed solutions.

Years 3 and 4

Typically, at the completion of year 4 students will be able to:

- recognise and write texts that persuade and explain, recognise that pictures or graphics can be important to add meaning, recognise different kinds of language to be used depending on the audience and purpose, plan and make presentations to the class, engage in discussions to share ideas and information, communicating clearly with others.
- choose strategies to add, subtract, multiply and divide represent the value of money and make simple calculations recall multiplication facts, represent fractions on a number line, explore addition, subtraction and multiplication number patterns, measure temperatures, lengths, shapes, and objects, solve problems involving time, and read maps, create symmetrical shapes, and classify angles construct graphs and list a likelihood of events.
- observe heat as a form of energy and investigate how it affects solids explore regular and predictable cycles through a study of day and night explore the action of forces
- realise that living things form parts of ecosystems, understand that actions of humans can influence their world.
- draw, measure, label, and model ideas when designing and producing solutions, plan steps to produce solutions and learn to manage their time, identify, and learn how to follow safety rules when working online, identify problems and solve them, create a range of digital solutions, such as coding simple interactive games.
- students develop a sense of self and ownership of their ideas and thinking about their peers and communities and as consumers. Students explore and learn to harness their creative, innovative, and imaginative ideas and approaches to achieve designed products, services, and environments. They do this through planning and awareness of the characteristics and properties of materials and the use of tools and equipment. They learn to reflect on their actions to refine their working and develop their decision-making skills. Students examine social and environmental sustainability implications of existing products and processes to raise awareness of their place in the world. They compare their predicted implications with real-world case studies including those from the Asia region and recognise that designs and technologies can affect people and their environments. They become aware of the role of those working in design and technologies occupations and how they think about the way a product might change in the future.
- using a range of technologies including a variety of graphical representation techniques to communicate, students clarify and present ideas, for example by drawing annotated diagrams; modelling objects as three-dimensional images from different views by visualising rotating images and using materials. Students recognise techniques for documenting design and production ideas such as basic drawing symbols and use simple flow diagrams.
- students become aware of the appropriate ways to manage their time and focus. With teacher guidance, they identify and list criteria for success including in relation to preferred futures and the major steps needed to complete a design task. They show an understanding of the importance of planning when designing solutions, in particular when collaborating. Students identify safety issues and learn to follow simple safety rules when producing designed solutions.

Years 5 and 6

Typically, at the completion of year 6 students will be able to:

- compare and analyse information, use evidence to explain their response to observations, using electronic devices to create texts about topics they have been studying, use speaking strategies including questioning, clarifying, and rephrasing to contribute to class discussions.
- place positive and negative numbers on a number line, add and subtract fractions and decimals, compare and interpret statistical graphs, continue and create sequences, involving whole numbers, fractions and decimals, and describe rules, measure length, area, volume, capacity and mass, and calculate perimeter and area of rectangles, list outcomes of chance experiments, apply fractions, decimals, percentages, angles and measurements to solve problems explain mental strategies for calculations, pose appropriate questions for statistical investigations.
- investigate adaptations in living things and their interactions with the environment, add gases to their study of materials and investigate chemical changes, investigate the solar system and the behaviour of light, understand how science influences community decisions.
- use materials or technologies when designing, producing, and evaluating solutions, represent ideas and solutions in a variety of ways, such as sketches and models, develop plans to complete tasks.
- use simple coding to develop and evaluate digital solutions, act to ensure their personal safety when engaging online, collect, interpret, and manage a range of data, using digital systems.
- students critically examine technologies – materials, systems, components, tools, and equipment – that are used regularly in the home and in local, national, regional, or global communities, with consideration of society, ethics, and social and environmental sustainability factors. Students consider why and for whom technologies were developed.
- students engage with ideas beyond the familiar, exploring how design and technologies and the people working in a range of technologies contexts contribute to society. They seek to explore innovation and establish their own design capabilities. Students are given new opportunities for clarifying their thinking, creativity, analysis, problem-solving and decision-making. They explore trends and data to imagine what the future will be like and suggest design decisions that contribute positively to preferred futures.
- using a range of technologies including a variety of graphical representation techniques to communicate, students represent objects and ideas in a variety of forms such as thumbnail sketches, models, drawings, diagrams, and storyboards to illustrate the development of designed solutions. They use a range of techniques such as labelling and annotating sequenced sketches and diagrams to illustrate how products function; and recognise and use a range of drawing symbols in context to give meaning and direction.
- students work individually and collaboratively to identify and sequence steps needed for a design task. They negotiate and develop plans to complete design tasks, and follow plans to complete design tasks safely, adjusting plans when necessary. Students identify, plan, and maintain safety standards and practices when making designed solutions.

Below is a checklist of learning areas and general capabilities that engineers should discuss with teachers when assisting teachers to design an engineering project.

This may be used as a template to discuss the engineering project design parameters with the teacher. Also, to assist with this process an "Engineering Cross Reference Tool to the Australian Curriculum" is provided here as an excel spreadsheet. This tool elaborates on the strands and sub-strands in the Australian curriculum against each of the learning areas and the general capabilities and allows you to map the intended learning areas and skills to a simplified engineering project process flow.

Project:

Primary School Level:

What are the learning needs of the students?

What learning outcomes are intended to be achieved?
How might the general capabilities be addressed in the project?

Literacy	
Numeracy	
ICT	
Critical and creative thinking	
Personal and social capability	
Ethics	
Intercultural understanding	

How might learning areas science, mathematics and technologies be addressed in the project?

Science

Which field(s) of science will be explored during the project? Biological sciences, chemical sciences, earth and space sciences, physical sciences.

Mathematics

Which strand(s) of mathematics will be the focus for the project? Number and algebra, measurement and geometry, statistics, and probability.

Technologies

Which technologies knowledge areas and processes will be the focus of the project?

Technologies and society, technologies contexts, engineering principles and systems, food and fibre production, food specialisations, materials and technologies, specialisation, investigating and defining, generating, and designing, producing, and implementing, evaluating, collaborating, and managing.

Digital systems, representation of data, collecting, managing, and organising data, investigating, and defining, generating, and designing, producing, and implementing, evaluating, collaborating, and managing.

How might Cross Curriculum Priorities such as sustainability be addressed in the project?

What key engineering thinking skills might be used in the project?

Computational thinking

Computational thinking is a process where a problem is analysed and solved so that a human, machine, or computer can effectively implement the solution. It involves organising data logically, breaking down problems into parts, interpreting patterns and designing and implementing algorithms to solve problems. Computational thinking is typically subdivided into four parts: decomposition, abstraction, pattern recognition and algorithms.

- Decomposition involves breaking down a problem into smaller parts.
- Abstraction involves identifying important information while ignoring unrelated or irrelevant details.
- Pattern recognition involves looking for trends or similarities in order to compare and group these things in meaningful ways.
- Algorithms involves creating a set of step-by-step instructions in order to complete a task or solve a problem.

Systems thinking

Systems thinking is the process of understanding how things influence one another within a whole system. It involves:

- Forming a holistic view of components that make up the system,
- Identifying the interdependencies of those components and how they are connected,
- Assessing changes to the system over time,
- Identifying the impact of actions of components within the system to the system as a whole and
- Assessing the likelihood, risk, and benefits of actions within the system.

What key engineering thinking skills might be used in the project? (continued)

Design thinking

Design thinking is the process used by engineers to understand problems, identify, implement, test, and improve solutions to problems. It involves asking, imagining, planning, creating, and improving.

- Asking (understand the problem, identify constraints, and technologies available to solve the problem),
- Imagining (identify possible solutions, estimate solution effectiveness),
- Planning (identify how will the solution be implemented, identify technologies and processes to be used),
- Creating (build the solution and test it), and
- Improving (evaluate test results identify areas for improvement, implement improvements).

Scientific thinking

Scientific thinking is the process of gaining scientific knowledge. It involves:

- Questioning and predicting (Identifying and constructing questions, proposing hypotheses, and suggesting possible outcomes),
- Planning and conducting (making decisions about how to investigate or solve a problem and carrying out an investigation, including the collection of data),
- Processing and analysing data and information (representing data in meaningful and useful ways, identifying trends, patterns, and relationships in data, and using this evidence to justify conclusions),
- Evaluating (considering the quality of available evidence and the merit or significance of a claim, proposition, or conclusion with reference to that evidence) and
- Communicating (conveying information or ideas to others through appropriate representations, text types and modes).

What key engineering thinking skills might be used in the project? (continued)

Critical thinking

Critical thinking is a general capability at the core of most intellectual activity that involves students learning to recognise or develop an argument, use evidence in support of that argument, draw reasoned conclusions, and use information to solve problems. Examples of critical thinking skills are interpreting, analysing, evaluating, explaining, sequencing, reasoning, comparing, questioning, inferring, hypothesising, appraising, testing, and generalising.

Creative Thinking

Creative thinking is a general capability that involves students learning to generate and apply new ideas in specific contexts, seeing existing situations in a new way, identifying alternative explanations, and seeing or making new links that generate a positive outcome. This includes combining parts to form something original, sifting, and refining ideas to discover possibilities, constructing theories and objects, and acting on intuition. The products of creative endeavour can involve complex representations and images, investigations and performances, digital and computer-generated output, or occur as virtual reality.

Secondary School

When working with a teacher to design an engineering project engineers should keep in mind the typical progression of students and intended linkages to the curriculum planned by the teacher. This is to ensure that expectations for the complexity and issues and problems being explored through the project are appropriately targeted to the student cohort. While engineering projects provide the opportunity for students to learn across many topics and gain a broad range of skills not all learning areas or general capabilities will necessarily need to be covered. It should be expected that the teacher will want to focus on particular elements to provide enable a quality learning experience for students.

For secondary school level these guidelines have been organised to cover progression from years 7 and 8 to years 9 and 10. For each of these levels the guidelines have included typical learning outcomes expected for each of these levels. Please note that these learning outcomes are indicative only and are provided to assist engineers to understand the likely learning outcomes that are likely to be pursued through the engineering project.
The teacher is the person best positioned to advise on the intended learning outcomes as the teacher will understand the capabilities of students and how the project is intended to fit with the planned syllabus.

Years 7 and 8

Typically, at completion of year 8 students will be able to:

- compare, analyse, and question ideas and information, select evidence to communicate their understanding of issues and problems, create texts for different purposes and audiences, present an argument and convey information, recognise, and use language features to clearly convey ideas, know and use words from technical and literary texts, give presentations that include visual and digital features.
- connect the known properties of arithmetic with the study of algebra, develop simple logical geometric arguments, find estimates of means and proportions of populations compare prices of products packaged in different quantities represent simple algebraic relations by graphs, calculate areas of shapes and volumes of simple solids apply ratios and interpret statistical graphs, calculate accurately with positive and negative numbers.
- further develop their understandings of systems through a study of ecosystems and cellular systems, explore renewable and non-renewable resources, and the applications of science to solve important issues, explore changes in matter at a particle level and link them to physical and chemical changes, investigate the role of energy in causing change in systems, consider ethical implications of scientific research and development.
- design, produce and evaluate solutions, create, and represent design ideas using a variety of techniques, such as modelling and drawing to scale, select a range of materials and equipment to produce solutions safely and efficiently, further develop their computational thinking, create a range of digital solutions, communicate, and collaborate online with an understanding of cyber-safety and legal responsibilities.
- students investigate and select from a range of technologies – materials, systems, components, tools, and equipment. They consider the ways characteristics and properties of technologies can be combined to design and produce sustainable designed solutions to problems for individuals and the community, considering society and ethics, and economic, environmental, and social sustainability factors. Students use creativity, innovation and enterprise skills with increasing independence and collaboration.

- students respond to feedback from others and evaluate design processes used and designed solutions for preferred futures. They investigate design and technology professions and the contributions that each makes to society locally, regionally, and globally through creativity, innovation, and enterprise. Students evaluate the advantages and disadvantages of design ideas and technologies.
- using a range of technologies including a variety of graphical representation techniques to communicate, students generate and clarify ideas through sketching, modelling, perspective, and orthogonal drawings. They use a range of symbols and technical terms in a range of contexts to produce patterns, annotated concept sketches and drawings, using scale, pictorial, and aerial views to draw environments.
- with greater autonomy, students identify the sequences and steps involved in design tasks. They develop plans to manage design tasks, including safe and responsible use of materials and tools, and apply management plans to successfully complete design tasks. Students establish safety procedures that minimise risk and manage a project with safety and efficiency in mind when making designed solutions.

Below is a checklist of learning areas and general capabilities that engineers should discuss with teachers when assisting teachers to design an engineering project.

This may be used as a template to discuss the engineering project design parameters with the teacher. Also, to assist with this process an "Engineering Cross Reference Tool to the Australian Curriculum" is provided here as an excel spreadsheet. This tool elaborates on the strands and sub-strands in the Australian curriculum against each of the learning areas and the general capabilities and allows you to map the intended learning areas and skills to a simplified engineering project process flow.

Project:
Secondary School Level Year 7/8:
What are the learning needs of the students?
What learning outcomes are intended to be achieved? How might the general capabilities be addressed in the project?
Literacy
Numeracy
ICT
Critical and creative thinking
Personal and social capability
Ethics
Intercultural understanding

How might learning areas science, mathematics and technologies be addressed in the project? What learning outcomes are intended to be achieved?

Science

Which field(s) of science will be explored during the project? Biological sciences, chemical sciences, earth and space sciences, physical sciences.

Mathematics

Which strand(s) of mathematics will be the focus for the project? Number and algebra, measurement and geometry, statistics, and probability.

Technologies

Which technologies knowledge areas and processes will be the focus of the project?

- Technologies and society, technologies contexts, engineering principles and systems, food and fibre production, food specialisations, materials and technologies, specialisation, investigating and defining, generating, and designing, producing, and implementing, evaluating, collaborating, and managing.
- Digital systems, representation of data, collecting, managing, and organising data, investigating, and defining, generating, and designing, producing, and implementing, evaluating, collaborating, and managing.

What key engineering thinking skills might be used in the project?

Computational thinking

Computational thinking is a process where a problem is analysed and solved so that a human, machine, or computer can effectively implement the solution. It involves organising data logically, breaking down problems into parts, interpreting patterns and designing and implementing algorithms to solve problems. Computational thinking is typically subdivided into four parts: decomposition, abstraction, pattern recognition and algorithms.

- Decomposition involves breaking down a problem into smaller parts.
- Abstraction involves identifying important information while ignoring unrelated or irrelevant details.
- Pattern recognition involves looking for trends or similarities in order to compare and group these things in meaningful ways.
- Algorithms involves creating a set of step-by-step instructions in order to complete a task or solve a problem.

Systems thinking

Systems thinking is the process of understanding how things influence one another within a whole system. It involves:

- Forming a holistic view of components that make up the system,
- Identifying the interdependencies of those components and how they are connected,
- Assessing changes to the system over time,
- Identifying the impact of actions of components within the system to the system as a whole and
- Assessing the likelihood, risk, and benefits of actions within the system.

What key engineering thinking skills might be used in the project? (continued)

Design thinking

Design thinking is the process used by engineers to understand problems, identify, implement, test, and improve solutions to problems. It involves asking, imagining, planning, creating, and improving.

- Asking (understand the problem, identify constraints, and technologies available to solve the problem),
- Imagining (identify possible solutions, estimate solution effectiveness),
- Planning (identify how will the solution be implemented, identify technologies and processes to be used),
- Creating (build the solution and test it), and
- Improving (evaluate test results identify areas for improvement, implement improvements).

Scientific thinking

Scientific thinking is the process of gaining scientific knowledge. It involves:

- Questioning and predicting (Identifying and constructing questions, proposing hypotheses, and suggesting possible outcomes),
- Planning and conducting (making decisions about how to investigate or solve a problem and carrying out an investigation, including the collection of data),
- Processing and analysing data and information (representing data in meaningful and useful ways, identifying trends, patterns, and relationships in data, and using this evidence to justify conclusions),
- Evaluating (considering the quality of available evidence and the merit or significance of a claim, proposition, or conclusion with reference to that evidence),
- Communicating (conveying information or ideas to others through appropriate representations, text types and modes).

What key engineering thinking skills might be used in the project?
(continued)

Critical thinking

Critical thinking is a general capability at the core of most intellectual activity that involves students learning to recognise or develop an argument, use evidence in support of that argument, draw reasoned conclusions, and use information to solve problems. Examples of critical thinking skills are interpreting, analysing, evaluating, explaining, sequencing, reasoning, comparing, questioning, inferring, hypothesising, appraising, testing, and generalising.

Creative Thinking

Creative thinking is a general capability that involves students learning to generate and apply new ideas in specific contexts, seeing existing situations in a new way, identifying alternative explanations, and seeing or making new links that generate a positive outcome. This includes combining parts to form something original, sifting, and refining ideas to discover possibilities, constructing theories and objects, and acting on intuition. The products of creative endeavour can involve complex representations and images, investigations and performances, digital and computer-generated output, or occur as virtual reality.

Project Management

Project management is the process of leading the work of a team to achieve all project goals within the given constraints.

How will careers in engineering be considered? What year 9 and 10 subjects are critical to an engineering career?

Years 9 and 10

Typically, at completion of year 10 students will be able to:

- compare and contrast ideas relating to identified issues and problems, justifying their own interpretations of their observations, navigate and analyse online information, explain different viewpoints and perspectives using logical arguments, create written and multimodal texts, edit, and refine their own work and provide constructive feedback to peers, plan, rehearse and deliver longer presentations with relevant and well-researched content.
- model practical situations involving surface areas and volumes solve problems involving right-angle trigonometry, calculate areas of shapes and volumes of simple solids, apply ratio and scale factors to similar figures, formulate geometric proofs
- interpret and compare datasets in statistics, explain the use of relative frequencies to estimate probabilities.
- investigate body systems and ecosystems as examples of interdependent, interactive systems, deepen their understanding of changes in chemical systems that can be caused by changes at the atomic level, investigate how the wave and particle theory can explain the behaviour of light, deepen their understanding of the physical laws of motion, critically analyse and evaluate claims and approaches used to solve problems, while considering ethics involved and how people's lives might be affected,
- explain how people working in design and technologies occupations consider factors that impact on design decisions and the technologies used to produce products, services, and environments, identify the changes necessary to designed solutions to realise preferred futures they have described, evaluate the features of technologies and their appropriateness for purpose for one or more of the technologies contexts.
- create designed solutions for one or more of the technologies contexts based on a critical evaluation of needs or opportunities, establish detailed criteria for success, including sustainability considerations, and use these to evaluate their ideas and designed solutions and processes, create and connect design ideas and processes of increasing complexity and justify decisions.
- communicate and document projects, including marketing for a range of audiences, independently and collaboratively apply sequenced production and management plans when producing designed solutions, adjusting plans, when necessary, select and use appropriate technologies skilfully and safely to produce high-quality designed solutions suitable for the intended purpose.
- students use design and technologies knowledge and understanding, processes and production skills and design thinking to produce designed solutions to identified needs or opportunities of relevance to individuals and regional and global communities. Students work independently and collaboratively. Problem-solving activities acknowledge the complexities of contemporary life and make connections to related specialised occupations and further study. Increasingly, study has a global perspective, with opportunities to understand the complex interdependencies involved in the development of technologies and enterprises. Students specifically focus on preferred futures, considering ethics; legal issues; social values; economic, environmental, and social sustainability factors and using strategies such as life cycle thinking. Students use creativity, innovation and enterprise skills with increasing confidence, independence, and collaboration.

- using a range of technologies including a variety of graphical representation techniques to communicate, students generate and represent original ideas and production plans in two and three-dimensional representations using a range of technical drawings including perspective, scale, orthogonal and production drawings with sectional and exploded views. They produce rendered, illustrated views for marketing and use graphic visualisation software to produce dynamic views of virtual products.
- students identify the steps involved in planning the production of designed solutions. They develop detailed project management plans incorporating elements such as sequenced time, cost, and action plans to manage a range of design tasks safely. They apply management plans, changing direction, when necessary, to successfully complete design tasks. Students identify and establish safety procedures that minimise risk and manage projects with safety and efficiency in mind, maintaining safety standards and management procedures to ensure success. They learn to transfer theoretical knowledge to practical activities across a range of project.
- critically consider the importance of engineering and science-based careers.

Below is a checklist of learning areas and general capabilities that engineers should discuss with teachers when assisting teachers to design an engineering project.

This may be used as a template to discuss the engineering project design parameters with the teacher. Also, to assist with this process an "Engineering Cross Reference Tool to the Australian Curriculum" is provided here as an excel spreadsheet. This tool elaborates on the strands and sub-strands in the Australian curriculum against each of the learning areas and the general capabilities and allows you to map the intended learning areas and skills to a simplified engineering project process flow.

Project:
Secondary School Level Year 9/10:
What are the learning needs of students?

How might the general capabilities be addressed in the project? What learning outcomes are intended to be achieved?
Literacy
Numeracy
ICT
Critical and creative thinking
Personal and social capability
Ethics
Intercultural understanding

How might learning areas science, mathematics and technologies be addressed in the project? What learning outcomes intended to be achieved?

Science

Which field(s) of science will be explored during the project? Biological sciences, chemical sciences, earth and space sciences, physical sciences.

Mathematics

Which strand(s) of mathematics will be the focus for the project? Number and algebra, measurement and geometry, statistics, and probability.

Technologies

Which technologies knowledge areas and processes will be the focus of the project?

- Technologies and society, technologies contexts, engineering principles and systems, food and fibre production, food specialisations, materials and technologies, specialisation, investigating and defining, generating, and designing, producing, and implementing, evaluating, collaborating, and managing.
- Digital systems, representation of data, collecting, managing, and organising data, investigating, and defining, generating, and designing, producing, and implementing, evaluating, collaborating, and managing.

What key thinking skills used by engineers might be used in the project?

Computational thinking

Computational thinking is a process where a problem is analysed and solved so that a human, machine, or computer can effectively implement the solution. It involves organising data logically, breaking down problems into parts, interpreting patterns and designing and implementing algorithms to solve problems. Computational thinking is typically subdivided into four parts: decomposition, abstraction, pattern recognition and algorithms.

- Decomposition involves breaking down a problem into smaller parts.
- Abstraction involves identifying important information while ignoring unrelated or irrelevant details.
- Pattern recognition involves looking for trends or similarities in order to compare and group these things in meaningful ways.
- Algorithms involves creating a set of step-by-step instructions in order to complete a task or solve a problem.

Systems thinking

Systems thinking is the process of understanding how things influence one another within a whole system. It involves:

- Forming a holistic view of components that make up the system,
- Identifying the interdependencies of those components and how they are connected,
- Assessing changes to the system over time,
- Identifying the impact of actions of components within the system to the system as a whole and
- Assessing the likelihood, risk, and benefits of actions within the system.

What key thinking skills used by engineers might be used in the project? (continued)

Design thinking

Design thinking is the process used by engineers to understand problems, identify, implement, test, and improve solutions to problems. It involves asking, imagining, planning, creating, and improving.

- Asking (understand the problem, identify constraints, and technologies available to solve the problem),
- Imagining (identify possible solutions, estimate solution effectiveness),
- Planning (identify how will the solution be implemented, identify technologies and processes to be used),
- Creating (build the solution and test it), and
- Improving (evaluate test results identify areas for improvement, implement improvements).

Scientific thinking

Scientific thinking is the process of gaining scientific knowledge. It involves:

- Questioning and predicting (Identifying and constructing questions, proposing hypotheses, and suggesting possible outcomes),
- Planning and conducting (making decisions about how to investigate or solve a problem and carrying out an investigation, including the collection of data),
- Processing and analysing data and information (representing data in meaningful and useful ways, identifying trends, patterns, and relationships in data, and using this evidence to justify conclusions),
- Evaluating (considering the quality of available evidence and the merit or significance of a claim, proposition, or conclusion with reference to that evidence),
- Communicating (conveying information or ideas to others through appropriate representations, text types and modes).

What key thinking skills used by engineers might be used in the project? (continued)

Critical thinking

Critical thinking is a general capability at the core of most intellectual activity that involves students learning to recognise or develop an argument, use evidence in support of that argument, draw reasoned conclusions, and use information to solve problems. Examples of critical thinking skills are interpreting, analysing, evaluating, explaining, sequencing, reasoning, comparing, questioning, inferring, hypothesising, appraising, testing, and generalising.

Creative Thinking

Creative thinking is a general capability that involves students learning to generate and apply new ideas in specific contexts, seeing existing situations in a new way, identifying alternative explanations, and seeing or making new links that generate a positive outcome. This includes combining parts to form something original, sifting, and refining ideas to discover possibilities, constructing theories and objects, and acting on intuition. The products of creative endeavour can involve complex representations and images, investigations and performances, digital and computer-generated output, or occur as virtual reality.

Project Management

Project management is the process of leading the work of a team to achieve all project goals within the given constraints.

How will careers in engineering be considered? What year 11 and 12 subjects are critical to an engineering career?

Professional engineer

A professional engineer designs, develops and analyses systems, applications and equipment relating to construction, production, operation, or maintenance. A professional engineer is responsible for applying engineering principles, data, and their specialist knowledge of applied science, including physics and chemistry, and mathematics to their work.

Further information is provided in Part 4.

Technologist

An engineering technologist uses some of the same skills as a professional engineer, but the roles differ in that an engineering technologist typically adopts and applies technologies or develops related technologies to create, operate, maintain, and improve the systems, applications and equipment originally designed by professional engineers.

Further information is provided in Part 4.

Associate

An engineering associate typically provides technical support to engineering professionals in research, design, manufacture, assembly, construction, operation and maintenance of machines and equipment, facilities, distribution systems and installations, they focus on specific elements of a system, operate within codes, and apply established practices and procedures prepare interpret inspect and revise drawings, plans, designs, maps, and charts.

Further information is provided in Part 4.

Senior secondary

In the Australian senior secondary curriculum, all states and territories have endorsed 15 subjects across english, mathematics, science, humanities and social sciences and describe how general capabilities are represented for each subject. State and Territory curriculum, assessment and certification authorities are responsible for determining how educational content and achievement standards are integrated into their courses. All states and territories have endorsed specific engineering or engineering related subjects within their senior secondary curriculums.

Details on the senior secondary curriculum structures and available courses can be found for each State/Territory through the links below.

ACT

ACT Board of Senior Secondary Studies

NSW

NSW Education Standards Authority

NT

Northern Territory Board of Studies

QLD

Queensland Curriculum and Assessment Authority

SA

SACE Board of South Australia

TAS

Office of Tasmanian Assessment, Standards and Certification

VIC

Victorian Curriculum and Assessment Authority

WA

School Curriculum and Standards Authority

Below is a list of engineering and related technology courses offered in each of the States and Territories for senior secondary students.

This list is provided for information only. As available courses, there structures, content and assessment criteria may change over time it is recommended that engineers working with teachers consult the websites above for authoritative information.

Senior secondary curriculum State/Territory syllabus related to engineering, design and technologies	
State/ Territory	**Courses**
ACT	Electronics and mechatronics
	Engineering studies
	Design and emerging technologies
	Design and technology
	Design and technology
	Design and graphics
	Designed environments
	Digital products
	Digital technologies
	Information technology
	Networking and security
	Robotics and mechatronics
NSW	Engineering studies
	Industrial technology
	Information processes and technology
	Software design and development
	Design and technology life skills
	Industrial technology
	Information processes and technology life skills

Senior secondary curriculum State/Territory syllabus related to engineering, design and technologies	
State/ Territory	**Courses**
NSW (continued)	Software design and development life skills
	Industrial technology life skills
	Technology life skills
NT	Computing applications
	Design, technology and engineering
SA	Digital technologies
	Design, technology and engineering
QLD	Digital technologies
	Aerospace systems
	Building and construction skills
	Design
	Digital solutions
	Engineering studies
	Engineering skills
	Industrial technology skills
TAS	Information and communication technology
	Automotive and mechanical technologies
	Basic computing
	Computer applications
	Computer graphics design
	Computer graphics design foundation
	Design and production

Senior secondary curriculum State/Territory syllabus related to engineering, design and technologies	
State/ Territory	**Courses**
TAS (continued)	Electronics and mechatronics
	Electronics foundation
	Engineering design
	Information systems and digital technologies
	Project implementation
	Technical graphics
VIC	Technical graphics foundation
	Product design and technology
	Systems engineering
	Algorithmics
WA	Applied computing
	Applied information technology
	Automotive engineering and technology
	Building and construction Skills
	Design
	Engineering studies
	Materials design and technology

Project:

Senior Secondary School Level Year 11/12:

What are the learning needs of students?

Are there any engineering projects approved by State/Territory Education Boards that would meet the needs of the students or could be adapted to meet the needs of students?

Will the project be undertaken as part of an approved senior secondary course? If so, which course(s) will be the target of the project?

How might the general capabilities be addressed in the project? What learning outcomes intended to be achieved?

Literacy

Numeracy

ICT

Critical and creative thinking

Personal and social capability

Ethics

Intercultural understanding

How might science, mathematics and technologies be addressed in the project? What learning outcomes are intended to be achieved?

Science

Which field(s) of science will be explored during the project? Chemistry, biology, earth and environmental science, physics.

Mathematics

Which mathematic subject(s) will be the focus for the project?
Essential mathematics, general mathematics, mathematical methods, specialist mathematics

How might science, mathematics and technologies be addressed in the project? What learning outcomes are intended to be achieved? (continued)

Technologies

What technologies, processes within the State/Territory syllabus will be covered by the project?

How might the project work be used to illustrate engineering career options for students?

What key engineering thinking skills might be used in the project?

Computational thinking

Computational thinking is a process where a problem is analysed and solved so that a human, machine, or computer can effectively implement the solution. It involves organising data logically, breaking down problems into parts, interpreting patterns and designing and implementing algorithms to solve problems. Computational thinking is typically subdivided into four parts: decomposition, abstraction, pattern recognition and algorithms.

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What key engineering thinking skills might be used in the project? (continued)

Systems thinking

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- Identifying the interdependencies of those components and how they are connected,
- Assessing changes to the system over time,
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What key engineering thinking skills might be used in the project? (continued)

Scientific thinking

Scientific thinking is the process of gaining scientific knowledge. It involves:

- Questioning and predicting (Identifying and constructing questions, proposing hypotheses, and suggesting possible outcomes),
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What key engineering thinking skills might be used in the project?
(continued)

Creative Thinking

Creative thinking is a general capability that involves students learning to generate and apply new ideas in specific contexts, seeing existing situations in a new way, identifying alternative explanations, and seeing or making new links that generate a positive outcome. This includes combining parts to form something original, sifting, and refining ideas to discover possibilities, constructing theories and objects, and acting on intuition. The products of creative endeavour can involve complex representations and images, investigations and performances, digital and computer-generated output, or occur as virtual reality.

Project Management

Project management is the process of leading the work of a team to achieve all project goals within the given constraints.

How will careers in engineering be considered? What year 11 and 12 subjects are critical to an engineering career?

Where students have not undertaken subjects that are prerequisites for entry to a tertiary level engineering course what bridging and other courses might students pursue to meet the necessary entrance requirements?

Professional engineer
A professional engineer designs, develops and analyses systems, applications and equipment relating to construction, production, operation, or maintenance. A professional engineer is responsible for applying engineering principles, data, and their specialist knowledge of applied science, including physics and chemistry, and mathematics to their work.
Further information is provided in Part 4.

Technologist
An engineering technologist uses some of the same skills as a professional engineer, but the roles differ in that an engineering technologist typically adopts and applies technologies or develops related technologies to create, operate, maintain, and improve the systems, applications and equipment originally designed by professional engineers.
Further information is provided in Part 4.

Associate
An engineering associate typically provides technical support to engineering professionals in research, design, manufacture, assembly, construction, operation and maintenance of machines and equipment, facilities, distribution systems and installations, they focus on specific elements of a system, operate within codes, and apply established practices and procedures prepare interpret inspect and revise drawings, plans, designs, maps, and charts.
Further information is provided in Part 4.

Having established the context for the engineering project in terms of school policies and risk appetite, the intended learning outcomes, the interests and capabilities of students, and the available resources and time constraints identify a need or problem to be solved.

Project:
School level Senior Secondary Year 11/12:
Identified need or problem:
Will the project be undertaken as part of a State/Territory approved course?
Are there any planned lead in activities relevant to the project? For example, presentations on engineering, course units to be undertaken as a prerequisite for the project.
Will the project be undertaken as a classroom activity, as a single lesson or multiple lessons? Or as an extracurricular activity?
What materials, equipment ICT resources will be required for students to undertake the project?
How will students explore the nature of the problem? For example, discussing the problem with people who are presenting the problem or in teams. How will the teacher facilitate the inquiry process? How will students record their observations?
How will students get an understanding of any constraints that need to be considered. For example, through measurements, experiments, analysis, or pattern recognition. How will students abstract irrelevant information? How will the teacher facilitate the inquiry process? How will students record their observations?
What materials, equipment ICT resources etc. will the teacher need?
How will students explore the characteristics of available materials and processes to establish constraints on the potential solutions? For example, through experiments with various materials and processes or modelling.
How will the teacher facilitate students gaining an understanding of the available technologies? How will students record their observations?
How will students explore options for potential solutions? For example, through brainstorming as a group or through facilitated discussion.

How will students establish criteria to select the preferred option to build or demonstrate?
How will students demonstrate their solution? For example, build a prototype and test it, develop a software program, and test it?
What materials, equipment, ICT resources will be available for students to demonstrate their solutions?
How will students record their plans to demonstrate and test their proposed solutions?
How will students record results of their testing? How will students evaluate the effectiveness of their solutions?
Will students be provided the opportunity to improve their solutions based on results of their testing?
Will students present their project findings? What sort of presentation would students need to undertake?
How will learning outcomes be assessed against the general capabilities?
How will learning outcomes be assessed against the learning areas?

Judging engineering projects

Usually when engineers are asked to participate in judging engineering projects the project has already been designed and is underway. The nature of the project competition can vary widely from class based, school based, regional, state, and national or international. In most cases the judging criteria and approach will have already been defined by the original designers.

There is a multitude of STEM competitions available for students and schools. These cover a range of curriculum areas. Some are run by subject organisations, some by governments, some by private organisations, some by international groups. For example, Aussie Educator has a list of competitions available in Australia.

When engineers are working with teachers in a judging role, the following issues should be addressed with the teacher that is leading the participation in the competition:

What is the best approach to engage with the teacher and school, to build and maintain relationships?
Is there a whole-school focus that the school community is currently concerned with that is planned to be addressed through the competition?
What level of access is expected of judges to students and teachers?
What is the planned duration of the project? For example, single lesson; multiple lessons; in classroom or extra curricula. Over one or several terms.
Will the competition be undertaken by students from the same class level or multiple class levels? For example, if the competition involves a team challenge students may be drawn from different classes.
What access might students have to expertise, mentoring or coaching?
What access do students have to resources to undertake the project?
What are the learning outcomes and assessment criteria for general capabilities (literacy, numeracy, ICT, critical and creative thinking, personal and social capability, ethics, and intercultural understanding) be addressed in the project? How is it planned that they be assessed?
What are the learning outcomes and assessment criteria for the science, mathematics and technologies elements covered in the project? How is it planned that they be assessed?
What are the relative weightings between the general capabilities and the mathematics, science, and technology elements?
Will the competition form part of students' formal assessments?

Have the competition outcomes been mapped to the Australian Curriculum (for Foundation to Year 10)? If not, is there a need to undertake a mapping to the Australian Curriculum? How might that mapping be done with the teacher?

"Engineering Cross Reference Tool to the Australian Curriculum" is provided here as an excel spreadsheet. This tool elaborates on the strands and sub-strands in the Australian curriculum against each of the learning areas and the general capabilities and allows you to map the intended learning areas and skills to a simplified engineering project process flow.

For senior secondary have the competition outcomes been mapped to the Australian Curriculum and relevant state curriculum/syllabus? If not, is there a need to undertake a mapping? How and who might do that mapping what would your involvement be working the teacher?

"Engineering Cross Reference Tool Senior Secondary Curriculum" is provided here as an excel spreadsheet. This tool elaborates on the strands and sub-strands for the 15 subjects in the Australian Curriculum against each of the learning areas and the general capabilities and provides a list of State and Territory engineering and technology related subjects. This tool allows you to map the intended learning areas and skills to a simplified engineering project process flow.

If mapping is considered necessary, what is the role of the teacher, engineer, or community members in undertaking the mapping?

What values and positive learning outcomes can be assessed from projects that have unexpected results or unintended outcomes? How can we recognize the benefits of errors, mistakes, malfunctions, leading edge developments?

What resources are available to judges?

What are students expected to do as part of the assessment process? For example, assessments against some learning outcomes and assessment criteria might be through team and/or individual presentations, preparation of reports, demonstration of project outcomes, explanation of analyses undertaken, explanation of the approach taken to understand the project and how decisions were made and rationale for any improvements.

What ideas, interests, and areas of expertise does the teacher want to convey through the competitive process?

Are there any guidelines available for judges? Will judging be undertaken by an individual or a team of judges?

What are the rules covering the competition?

Part 4: Pathways to a career in engineering for Australian school students

Introduction

These guidelines on engineering career pathways are designed for engineers, students, teachers, parents, and career advisers assisting students interested in a career in engineering.

What does an engineer do?

Specific roles and requirements will vary according to each specialisation, but broadly speaking, **engineers create technology solutions to solve problems using mathematics, and science to understand the problem, design and improve the solution.**

There are several branches and specialisations of engineering such as the main fields of biomedical, chemical, civil, electrical, environmental, mechanical, information, telecommunications, electronics, and structural engineering.

These branches and specialisations are continuously evolving and changing, with advances in technology and scientific knowledge, changing priorities in society and environment, and new fields of interest and human ingenuity. Studies of modern history and human development are inexorably linked to advances in science, technology, and engineering achievement.

There is also a very broad range of fields of engineering practiced by engineers with qualifications in the above disciplines or with qualifications in more specialised fields. These include fields of practice such as: naval architecture, systems engineering, marine and offshore engineering, mechatronics, photonics, petroleum, mining, subsea, manufacturing, instrumentation, control and automation, microelectronics, optoelectronics, polymer, automotive, space, ceramics, photovoltaics and solar energy, textiles, materials, aerospace and aeronautical, agricultural.

These specialisations and fields illustrate the enormous scope of possibilities in engineering in society. Contrary to many typecast characters and depictions in modern culture, engineers often have varied careers in exciting environments. It is a creative and rewarding profession that offers employment in almost all sectors of the Australian economy.

When considering a career in engineering students should consider:

- whether their skills, interests and personal attributes match with those that are characteristic of engineers
- what type of work would most suit their interests and skills, for example hands on or theoretical?
- what sciences and technologies are of the most interest?
- what balance of theoretical knowledge and practical application skills and experience is preferred?

Foundation skills and attributes

Several foundation skills and attributes are well recognised for engineers, including:

Problem solving

Engineers must be able to use their problem-solving skills to create more effective systems and processes. This involves using logic, common sense, and analytical skills to analyse, evaluate, and synthesize information to make objective judgements and recommendations. Associated attributes include adaptability, flexibility, and teamwork.

Innovation and creativity

As engineers are required to challenge existing processes and current ways of thinking, much of the work involves innovation and creativity. 'Thinking outside the box' is a necessary skill for any engineer to create new and transformative solutions to problems faced within society. This innovation also requires adaptability and improvisational skills, the ability to creatively apply lateral solutions, sometimes in new environments and situations.

Curiosity

Being curious is one of the most vital characteristics needed to become an engineer. Engineers need to be curious about community needs as well as science and technology in order to question current ways of living and working in order to improve and develop new products or ideas.

Attention to detail

Engineers pay attention to the finer details as this could have a detrimental effect on the functionality and effectiveness of a project. Engineers are often given the responsibility for complex plans and developments which need to be followed rigorously to avoid any complications. This means having a keen eye for detail and an ability to plan. For many engineering roles, there can be several phases including conceptual, planning, implementation, and testing.

Mathematical capability

An understanding of mathematical principles is critical as mathematics is a major input into problem-solving to understand problems analyse the effectiveness of proposed solutions and improving solutions. They must be able to understand the type of calculations required to ensure the correct design is developed.

Teamwork

As the work of engineers is usually multifaceted and complex, engineers work in teams, as such teamwork and collaborative skills are very important to ensure that everyone is working towards the same goal and team members understand their respective roles and responsibilities.

Communication skills

Engineers need to be able to express ideas verbally and in writing to a range of audiences. Most projects will involve teamwork and contributions from a range of stakeholders, such as the community, customers, people from other disciplines which requires good communication and people skills.

Leadership

In addition to working well within a team, engineers across all disciplines need to take the lead on a project or elements of a project assigned to them. Leadership includes applying a blend of motivational, listening, planning, coordination, communication, task monitoring and control techniques to effectively harness the engineering expertise and skills of other people, to achieve strategic goals.

Categories of engineers

In Australia there are three recognised occupational categories related to engineering. Engineers Australia is the peak body within Australia for accrediting engineering programs by which engineers are recognised to enter engineering practice. Each category requires a different level of education, involves people in different types of work and different types of responsibility when working in an engineering team.

The categories are:

Professional Engineer

A professional engineer designs, develops and analyses systems, applications and equipment relating to construction, production, operation, or maintenance. A professional engineer is responsible for applying engineering principles, data, and their specialist knowledge of applied science, including physics and chemistry, and mathematics to their work. Professional engineers:

- Focus on overall systems
- Develop and apply new engineering practices
- Apply leadership and management skills
- Pursue engineering opportunities in an holistic way, taking environmental, community and social issues into account
- Solve diverse problems.

Engineering Technologist

An engineering technologist uses some of the same skills as a professional engineer, but the roles differ in that an engineering technologist typically adopts and applies technologies or develops related technologies to create, operate, maintain, and improve the systems, applications and equipment originally designed by professional engineers. Engineering technologists:

- Cooperate with engineers from related fields to carry out interdisciplinary work
- Design blueprints and plans for ongoing and future engineering projects
- Supervise the work of other engineers in relevant areas
- Modify and adapt established engineering practices
- Optimise operations and support of critical systems and capabilities

Engineering Associate

An engineering associate typically provides technical support to engineering professionals in research, design, manufacture, assembly, construction, operation and maintenance of machines and equipment, facilities, distribution systems and installations, they focus on specific elements of a system, operate within codes, and apply established practices and procedures prepare interpret inspect and revise drawings, plans, designs, maps, and charts. Engineering associate:

- Assist engineers with the designs and layouts
- Collect information, perform calculations, and prepare diagrams and drawings
- Determine material costs and quantities
- Check that designs and finished products follow specifications, regulations, and contract details
- Use computers to produce designs, detailed drawings, and documentation
- Assist with testing and starting up equipment and installations, and in supervising operations and maintenance

There is a more detailed description of each of these categories on our website.

When considering a career in engineering students should consider which type of work would suit them best as this will affect the engineering courses that they investigate. They should also anticipate that their progression and development will be enhanced by working in multidisciplinary teams, often including users, architects, project managers, operators, business, legal, trainers, and human factors professions.

Subjects

Students interested in pursuing an engineering career should enrol in mathematics, science, and english during years 11 and 12. They should also consider enrolling in STEM related courses if offered by their school or participate in engineering projects or competitions if available. All States and Territories include engineering courses in their senior secondary curricula. These courses provide students with the opportunity to learn about engineering practice but are not available in all schools. Below is an indicative list of engineering and related technology courses available in each State and Territory.

Senior secondary curriculum State/Territory syllabus related to engineering, design and technologies

State/ Territory	Courses
ACT	Electronics and mechatronics
	Engineering studies
	Design and emerging technologies
	Design and technology
	Design and technology
	Design and graphics
	Designed environments
	Digital products
	Digital technologies
	Information technology
	Networking and security
	Robotics and mechatronics
NSW	Engineering studies
	Industrial technology
	Information processes and technology
	Software design and development
	Design and technology life skills
	Industrial technology

Senior secondary curriculum State/Territory syllabus related to engineering, design and technologies	
State/ Territory	**Courses**
NSW (continued)	Information processes and technology life skills
	Software design and development life skills
	Industrial technology life skills
	Technology life skills
NT	Computing applications
	Design, technology and engineering
SA	Digital technologies
	Design, technology and engineering
QLD	Digital technologies
	Aerospace systems
	Building and construction skills
	Design
	Digital solutions
	Engineering studies
	Engineering skills
	Industrial technology skills
TAS	Information and communication technology
	Automotive and mechanical technologies
	Basic computing
	Computer spplications
	Computer graphics design
	Computer graphics design foundation

Senior secondary curriculum State/Territory syllabus related to engineering, design and technologies

State/ Territory	Courses
TAS (continued)	Design and production
	Electronics and mechatronics
	Electronics foundation
	Engineering design
	Information systems and digital technologies
	Project implementation
	Technical graphics
VIC	Technical graphics foundation
	Product design and technology
	Systems engineering
	Algorithmics
WA	Applied computing
	Applied information technology
	Automotive engineering and technology
	Building and construction skills
	Design
	Engineering studies
	Materials design and technology

Traditional pathway

The traditional pathway to becoming an engineer in Australia is to undertake an accredited engineering program conducted by a university or a Vocational Education and Training (VET) organisation i.e., a Recognised Training Organisation (RTO) or Technical and Further Education (TAFE) following completion of Year 12 and having satisfied the admissions criteria for the selected course.

The recognised academic qualifications for each of the engineering levels are:

Professional Engineer	Accredited minimum four-year Australian Bachelor of Engineering (Hons) degree or accredited Australian Master of Engineering degree
Engineering Technologist	Accredited three-year Australian Bachelor of Engineering Technology or Engineering Science degree
Engineering Associate	Accredited two-year Australian (AQF) Advanced Diploma or Associate Degree from an Australian university or vocational education and training organisation

To assist with identifying suitable courses the National Careers Institute website allows students, parents, teachers, and engineers to search for suitable courses based on several criteria such as area of study, level of qualification, course duration, location, and delivery mode (full time/part time).

This site provides information on prerequisites, admission criteria and career opportunities for each course. Links to the various universities, Technical and Further Education (TAFEs) and Registered Training Organisations (RTOs)are also provided to obtain further information.

In addition to this site the My Skills website provides the national directory of vocational education and training (VET) organisations and courses, and provides the ability to search for, and compare, VET courses and training providers. The link can be found here.

Admissions criteria

The majority, if not all, of three-, four- and five-year engineering degree courses require year 12 mathematics, english and science and usually a minimum Australian Tertiary Admission Rank (ATAR). The prerequisites and ATAR vary between institutions.

Associate degrees and advanced diplomas offered by Universities and Vocational Education and Training organisations usually require successful completion of Year 12 as well as mathematics as a prerequisite.

Alternate pathways

For students that do not have the required prerequisites or have not met the ATAR required for admission to an engineering course at the completion of Year 12 there is a range of alternative options available. These include:

- Undertaking an undergraduate award (6 month) course in engineering (offered by some universities)
- Undertaking a Certificate III or higher in engineering or related area to gain additional education to qualify for admission into a recognised engineering course.
- Undertaking a bridging course or foundation studies program offered by the preferred university or recognised by the preferred university.
- Undertaking a Special Tertiary Admission Test (STAT) if a suitable ATAR was not gained and STAT results are accepted by the institution for the intended course.
  More information on STAT can be found on their website.
- Undertaking a vocational education and training course to enter a trade related to engineering with the view to undertaking further education later to qualify as a recognised engineer. Most universities and VET organisations offering courses that lead to an engineering qualification are flexible in recognition of trade related courses and recognition of prior learning to facilitate entry to engineering courses.
  - The YourCareer website provides more information on becoming an apprentice, and the myskills website provides more information on VET courses and which providers are offering them.

Accredited engineering courses in Australia

Australian engineering courses accredited by Engineers Australia can be found on our website. In addition to undertaking the academic course components Engineers Australia requires accredited programs at all levels (Professional Engineer, Engineering Technologist and Engineering Associate) include professional practice experience delivered in environments (which may be simulated, virtual, industry or a mix of these) that provide experiential learning.

Typically, this experience is achieved through internships, scholarships, or cadetships, where students gain work experience usually during vacation periods.

Depending on the education institution internships may be organised by the education institution or organised by the student. Cadetships and scholarships are typically applied for by the students through a competitive process.

Students completing any of these courses will have their qualifications recognised by Engineers Australia for entry into the engineering profession at the level of professional engineer, engineering technologist or engineering associate as applicable. Students' qualifications will also be recognised internationally for entry to the profession.

Study assistance

There is a broad range of options for gaining assistance to study engineering. These include:

Commonwealth Supported Place

- A Commonwealth Supported Place (CSP) is a place at a university or higher education provider where the government pays part of the fees. This part is a subsidy, not a loan, and you don't have to pay it back. This subsidy does not cover the entire cost of study. Students must pay the rest, called the 'student contribution amount'. Being eligible for a CSP does not mean that a student will be offered a CSP as each provider and each course can have its own extra entry requirements. Education providers that offer Commonwealth assistance can be found on the Study Assist website.

HELP Loans

- Students enrolled in a Commonwealth Supported Place (CSP) outlined above, can apply for a HECS-HELP loan to pay their student contribution.
- Students who are not enrolled in a CSP, but are enrolled in a full a fee paying place can apply for a FEE-HELP loan to pay fees.
- To pay fees associated with student services and amenities students can apply for SA-HELP loan to cover these fees.
- Students enrolled in a CSP and want to study overseas, can apply for an OS-HELP loan to help pay for their expenses.

More information on HELP loans can be found on the Study Assist website.

Internships

- Some companies offer paid internship programs designed to enable students to gain real life experience on engineering projects and case studies working with experienced engineers during their course. These usually operate during the December to February vacation period and may be organised or facilitated by the education institution through their industry partnerships or are applied for by students.

Scholarships

- Commonwealth funded scholarships – there is a range of Commonwealth funded scholarships that students can apply for. More information on these scholarships can be found on the Study Assist website.
- University scholarships – many Australian universities offer a wide range of scholarships for students studying engineering. The availability and nature of scholarships can be found by visiting the various university websites.
- Company scholarships – some Australian companies offer engineering scholarships designed to encourage and support students to undertake engineering courses in fields of interest to those companies.

Cadetships

- Some Federal, State, and local Government agencies such as Defence, as well as Australian companies, offer cadetships for students undertaking engineering qualifications. Cadetships typically offer students employment while they undertake their studies, pay course and other fees, and provide students with practical experience.

Women in STEM

The Australian Government, recognising that there are gender equity issues, including a gender pay gap with girls and women participating in STEM related careers such as engineering, has funded several programs. The Government monitors gender equity progress through the STEM Equity Monitor, a national data report on girls and women in science, technology, engineering, and mathematics (STEM). The Monitor reports the current state of STEM gender equity in Australia, and measures changes and trends. It follows the participation of women in STEM through school, higher education, graduation, and the workforce as well as information on perceptions and attitudes. More information can be found on the Government's STEM page.

The Girls In STEM toolkit GiST, provides resources to inspire and inform girls, schools and families in science technology engineering and mathematics.

Another, Curious Minds is hands-on extension program for Year 9 and 10 girls that combines residential/webinar camps and a mentoring program to ignite girls' passion in STEM.

Useful sources of additional information

The following programs and resources may be of interest to engineers working with teachers, parents, and career advisors.

- Digital Technologies Hub - An online resource portal that supports implementation of the Australian Curriculum: digital technologies for teachers, students, and families. The Hub includes Curriculum linked, quality assured learning resources, lesson plans and activities.
- National Lending Library - The University of Adelaide's Massive Open Online Courses (MOOCs) provide free professional development for teachers on the Digital Technologies curriculum, including Artificial Intelligence (AI) and emerging technologies. The initiative also provides professional learning opportunities and free access to the latest digital technologies equipment, including AI and emerging technology kits.
- Australian Academy of Science programs (Primary Connections, Science by Doing and Resolve) – provide a range of science and mathematics curriculum resources and professional learning for teachers.
- CSIRO's STEM Professionals in Schools - A program that partners teachers with STEM professionals to enhance STEM teaching practices and deliver engaging STEM education in Australian schools.

Fields of engineering

Engineering is a dynamic profession with evolving fields, responding to changes in human needs and advances in scientific knowledge and technologies. The main engineering branches include:

Biomedical

Biomedical engineering combines a knowledge and practice of electronic, electrical, mechanical, chemical and materials engineering, with the life sciences of medicine, biology, and molecular biology. Modern medical imaging and diagnostics, instrumentation and data management technologies are important in improving health standards and medical advances.

Chemical

Chemical engineers use the principles of chemistry, mathematics and physics, sometimes alongside other areas like biology, to investigate and solve problems. They often integrate economics, digital technology, legal, software programming, and systems engineering to design safe and efficient solutions. Chemical engineers are often involved in advances in fuels and energy, catalytic processes, medical developments, industrial process control, battery technologies and energy management.

Civil

Civil engineers facilitate the solving of problems for the benefit and advancement of our communities through the installation and management of infrastructure, structures, cities, working environments, transport and industrial facilities, coastlines, mines, geological structures, waterways using mathematics and scientific principles.

Electrical

Electrical engineering is concerned with research, design, development, manufacture, installation, commissioning, operation, maintenance and management of equipment, plant, and systems within the electrical, electronic, laser, optical, communication and computer systems areas. Power generation and distribution, conversion, switching, electromechanical and associated control and optimisation systems are important in modern societies and managing effects on the environment.

Environmental

Environmental engineers are concerned with protecting the environment by assessing the impact a project has on the air, water, soil, landscapes, coastlines, and sensitive receptors in its vicinity. This is done by studying the project's design, construction, and operation, and avoiding or minimising any adverse effects that it may have on the environment. Environmental engineers are increasingly involved in better practices in mining, drilling, extractive industries, water management and landcare.

Information, telecommunications and electronics

Information, telecommunications and electronics engineers apply scientific theory and engineering design to develop: computer modelling tools to generate and analyse information used in communication, sciences and society (e.g. weather-mapping and statistics); broadband capability and improvement of telecommunications systems; hardware and software used in manufacturing, traffic urban management, hospitals, government services and scientific organisations; systems for media broadcasting and sound, including antennas and wireless technologies and sophisticated electronics (e.g. medical equipment, aircraft systems, robotics) and control systems. With greater use of computing and web-based systems in society, cyber systems design and threat response systems are increasingly important.

Mechanical

Mechanical engineering is concerned with the design, development, research, evaluation, manufacture, installation, testing, operation, maintenance and management of machines, mechanical and mechatronic systems, automated systems and robotic devices, heat transfer processes, thermodynamic and combustion systems, fluid and thermal energy systems, materials and materials handling systems, manufacturing equipment and process plant.

Structural

Structural engineering is concerned with the research, planning, design, construction, inspection, monitoring, maintenance, rehabilitation, and demolition of permanent and temporary structures, as well as structural systems and their components. It also considers the technical, economic, environmental, aesthetic, and social aspects of structures. Structural systems are designed, built, and managed at increasingly diverse scales, from nanotechnologies to megastructures.

Aeronautical and Aerospace

Aeronautical and aerospace engineers apply combinations of mechanical, propulsion, fluid flow, structural, electronics, computing, information processing, automation and human systems to the design, development, research, test and evaluation, build and maintenance, operations and management of aerospace vehicles and systems in atmospheric and space environments, with high emphasis on safety, performance, reliability, availability and endurance of systems and vehicles.

ENGINEERS
AUSTRALIA

Working with teachers on STEM projects

An engineers guide

Author:

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