ENGINEERS
AUSTRALIA

Engineering in the Australian curriculum

F-Year 10 and Senior Secondary

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

There is no discrete definition of engineering or engineering capabilities in the Australian curriculum, unlike mathematics, science and technology. Rather, for Foundation to Year 10, engineering is addressed primarily across three learning areas: Science, Technologies and Mathematics, and through a specific focus on engineering principles and systems in the Design and Technologies strand within Technologies learning area.

Additionally, the Processes and Production Skills strand of Technologies, which is defined as 'creating designed solutions by investigating and defining; generating and designing; producing and implementing; evaluating; and collaborating and managing', includes many key elements of the engineering process.

Engineering skills are also taught and practiced by application of the General Capabilities in the Australian curriculum, particularly Literacy, Numeracy, Information and Communication Technology (ICT) and Critical and Creative Thinking. Through undertaking engineering projects, students also develop skills in the other General Capabilities of Personal and Social Capability, Ethical Understanding and Intercultural Understanding, depending on the nature of the project.

In the Australian curriculum, the term capability encompasses knowledge, skills, behaviours and dispositions. Students develop capability when they apply knowledge and skills confidently, effectively and appropriately in complex and changing circumstances in their learning at school and in their lives outside school.

By undertaking engineering projects students learn the fundamentals of engineering by applying the engineering process, which can be simply described as:

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

For 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 subjects within their senior secondary curriculum and endorsed at least one engineering related subject.

Literacy

Students undertaking engineering projects use literacy to understand the nature and real-world context of the problem to be solved, understand constraints and investigate technologies that might be applied to solving the problem, through making enquiries and interacting with others. Students develop literacy as they learn to communicate their understanding of the problem, communicate their ideas, concepts and proposals for solutions to a variety of audiences. They use literacy to pose and answer questions, engage in mathematical problem-solving and to discuss, produce and explain solutions. Language structures are used to link information and ideas, give descriptions and explanations of how the proposed solution will work and construct evidence-based testing to evaluate solution effectiveness.

Students learn to read and interpret written instructions for technology solutions, often including diagrams and procedural writings such as software, user manuals, design briefs and patterns; prepare accurate, annotated engineering drawings, software instructions and coding; write project outlines, briefs, concept and project management proposals, evaluations, life cycle and project analysis reports; and prepare detailed specifications for production. Students learn to present and evaluate data, give explanations of testing results and present options for improving solutions.

By learning the literacy of mathematics, science and technologies, engineering students understand that language varies according to context and they increase their ability to use language flexibly. Mathematics, science and technologies vocabulary is often technical and includes specific terms for concepts, processes and production. Students learn to understand that much technological information is presented in the form of drawings, diagrams, flow charts, models, tables and graphs. They consequently learn to apply and use these alternative information formats. They also learn the importance of listening, talking and discussing technologies processes, especially in articulating, questioning and evaluating ideas.

Senior secondary engineering projects provide students with the opportunity to further enhance their literacy skills when they interpret the nature of more complex problems to be solved, employ strategies to communicate their understanding of the problem, possible solutions, testing outcomes and potential improvements. These projects provide a context for students to develop their abilities to read, write, visualise and discuss complex situations involving a range of scientific, mathematical and technological ideas. Students can apply and further develop their literacy skills and strategies by shifting between verbal, graphic, numerical and symbolic forms of representing complex problems in order to formulate, understand and solve problems, communicate results and persuade others. This process of translation across different systems of representation is essential for engineering projects involving complex scientific and mathematical reasoning and expression.

When undertaking senior engineering projects, students gather, interpret, synthesise and critically analyse information presented by the project (including text, flow diagrams, symbols, graphs and tables). They evaluate information sources, compare and contrast ideas, information and options being considered to solve complex problems. They learn to communicate processes and ideas logically and fluently to structure evidence-based arguments, selecting options and employing appropriate structures and features to communicate persuasively to a variety of audiences. Students learn to communicate their findings and test results in different ways, using multiple systems of representation and data displays to illustrate the relationships associated with the problem and potential solutions and describe their observations of the effectiveness of the solution that they have constructed.

Numeracy

Engineering projects give students opportunities to apply mathematical understanding and skills in context in a range of real-life situations to understand the characteristics of the problem, develop workable solutions to problems, undertake practical measurements, collect, present and interpret data from investigations and test results.

Students undertaking engineering projects use numeracy skills and understanding to calculate, measure and estimate key parameters to understand the scope of the problem, understand the constraints impacting the design of solutions; generate ideas to solve the problem, produce the chosen solution and develop and refine test concepts. They measure and record data throughout this process.

Students interpret and draw conclusions from data collected during the exploratory phase to understand the problem and solution constraints, to evaluate the suitability of potential options

and decide on the best solution. They use mathematical concepts to develop the solution design within the constraints of the identified problem and the nature of materials available to solve the problem.

Students work with a number of numerical concepts to sequence production and, depending on the nature of the project, develop cost and material estimates and manage the project.

Using software, materials, tools and equipment students can develop models to prototype or simulate potential solutions, create technical drawings, work with digital models and use computational thinking in decision-making processes when designing, improving and creating best-fit solutions.

Students undertaking senior secondary engineering projects are provided with opportunities to further develop their numeracy skills as they analyse more complex data, interpret trends and understand relationships associated with the problems that they are working to solve. They employ numeracy skills to interpret or simplify complex spatial and graphic representations, and to appreciate the ways in which physical systems are structured, interact and change.

They engage in analysis of data, including issues relating to reliability and probability, and they interpret and manipulate mathematical relationships to calculate and predict performance of potential solutions. Students use numeracy skills when they propose potential solutions and present arguments to support the solution option being recommended. They draw conclusions from statistical information, interpret and use quantitative data as evidence and prepare and compare financial implications of the options.

Information and Communications Technology

When undertaking engineering projects students develop ICT capability when they investigate and communicate scientific characteristics of the problem and explore properties of technologies (materials, systems and processes) available to solve the problem. Students also apply and develop their ICT skills when they investigate, create and communicate mathematical ideas and concepts related to the problem and investigate the feasibility of technology solutions.

In particular, students use their ICT capability to access information, collect, analyse and represent data, and model and interpret science and mathematics concepts and relationships. They also use ICT capability to communicate their understanding of the problem, potential ideas to solve the problem and processes to implement, test and improve solutions.

Students also use their ICT capability to perform calculations, draw graphs, collect, manage, analyse and interpret data, share and exchange information and ideas, and investigate and model concepts and relationships. Digital aids such as animations and simulations provide opportunities to view scientific and mathematical characteristic of the problem and test predictions on how potential solutions might solve the problem.

When undertaking projects involving digital technologies, students develop an understanding of the characteristics of data, digital systems, audiences, procedures and computational thinking. They apply this when they investigate problems, communicate their analysis of problems and potential technology solutions, create and improve digital solutions.

Students learn to formulate problems, logically organise and analyse data and represent them in abstract forms. They automate solutions using computational thinking to decompose the problem, recognise patterns, identify important information and use algorithmic logic to design steps to solve problems. Students decide the best combinations of data, procedures and human and physical resources to generate efficient and effective digital solutions. They create digital solutions that consider economic, environmental and social factors.

Digital technologies, such as spreadsheets, dynamic geometry software and computer algebra software, can engage students and promote understanding of key concepts. Digital aids such as animations and simulations provide opportunities to view phenomena and test predictions on how potential solutions might solve the problem.

Technology can be used to access information on scientific phenomena associated with problems and the properties of technologies available to solve problems to improve students' understanding of scientific and technology concepts, ideas and feasibility of potential solutions.

When undertaking senior secondary engineering projects students use a range of strategies to locate, access and evaluate information from multiple digital sources, to collect, analyse and represent data, to model and interpret concepts and relationships, and to communicate and share many types of information related to the problem, ideas for potential solutions, processes for solution implementation and information related to solution evaluation.

When undertaking these projects, students use ICT to develop mathematical understanding and to apply mathematical knowledge to the problem being solved. They use software aligned with the nature of the problem such as for statistical analysis, data representation and manipulation, and complex calculation. They use digital tools to make connections between mathematical theory, practice and application; for example, using data, addressing problems and operating systems in authentic situations.

They develop skills in creating digital and multimodal texts and create texts using different modes and mediums to communicate with their stakeholders and team members.

Critical and Creative Thinking

Engineering projects help students develop capability in critical and creative thinking as they learn to generate and evaluate knowledge, ideas and possibilities, and use them develop ideas for solutions to problems.

Critical and creative thinking skills are developed by posing questions, making predictions, speculating on potential solutions to problems, building selected solutions, making evidence-based decisions and analysing and evaluating evidence on solution effectiveness. Students develop understandings of concepts through active inquiry that involves planning and selecting appropriate information, evaluating sources of information to formulate conclusions, and to critically reflect on their own and the collective team process.

Students also develop critical thinking as they use mathematical principles to evaluate knowledge, ideas and possibilities and use them to build and evaluate solutions. Students are encouraged to be critical thinkers when justifying their choice of a calculation strategy or identifying relevant questions during their investigations of the nature of the problem to be solved, and possible technologies available to solve problems. They consider how data, information, systems, materials, tools and equipment impact on our lives, and how these elements might be better designed and managed.

Engineering projects promote critical and creative thinking by encouraging flexibility and open-mindedness as students speculate about their observations of the problem, then develop and evaluate ideas to solve problems.

Experimenting, drawing, modelling, designing and working with digital tools, equipment and software helps students to build their visual and spatial thinking. Students develop capability in critical and creative thinking as they imagine, generate, develop and critically evaluate ideas to solve problems.

Students analyse problems and requirements, refine concepts and reflect on the decision-making process by engaging in systems, design and computational thinking. They identify, explore and clarify technologies information and use that knowledge in the engineering process.

Engineering projects provide students with the opportunity to analyse problems, refine concepts and reflect on the decision-making process by engaging in systems, design and computational thinking. They identify, explore and clarify technologies information and use that knowledge in a range of situations.

Senior secondary engineering projects provide opportunities for students to develop their ability to construct, review and revise questions and hypotheses about increasingly complex problems and then to design related investigation methods to understand the problem and analyse potential solutions. Students interpret and evaluate data, interrogate, select and cross-reference evidence and analyse processes, interpretations, conclusions and claims for validity and reliability, including reflecting on their own processes and conclusions. They learn to assess risks of requirements not being met, of solutions introducing new problems.

Students adapt and devise innovative solutions to the problem, predict possibilities, envisage consequences and speculate on possible outcomes. They also appreciate the role of critical and creative individuals and the central importance of critique and review in the development and implementation of innovative solutions.

Students compare predictions of solution effectiveness with observations of test results when evaluating solution performance. They check the extent to which their predictions match observations. They assess whether, if observations and predictions do not match, it is due to a flaw in the assumptions used, flaws in the design or in the methods used to make predictions. They revise their design, to mitigate risks and propose improvements.

Personal and Social Capability

Through engineering projects, students develop personal and social capability as they engage in science inquiry, learn how scientific knowledge informs and can be applied to solve real life problems that they can relate to in their daily lives. This includes developing skills in communication, initiative taking, goal setting, prioritising requirements, interacting with others and decision-making and the capacity to work independently and collaboratively.

Students enhance personal and social capability by expanding their capacity to question, solve problems, explore and display curiosity. Students use their knowledge of scientific and mathematical principles and technologies to make informed choices about issues that impact their lives, then consider the application of science and technology to meet a range of personal and social needs.

Students develop personal and social capability as they engage in project management in a collaborative workspace. They direct their own learning, plan and carry out investigations and become independent learners who can apply design thinking, technologies understanding and skills when making decisions.

Students develop important networking, social and employability skills by working cooperatively in teams, sharing resources and processes, making group decisions, resolving conflict and showing leadership. Designing and innovation involve a degree of risk-taking, and as students work with the uncertainty of sharing new ideas, they develop resilience.

Students develop understanding of diversity by researching and identifying user needs in the problems that they are trying to solve. They consider impacts of decisions on people, communities and environments and develop social responsibility through understanding of,

empathy with and respect for others.

Through planning and building solutions to problems, students learn such things as time management, budgeting and financial management and understanding and using statistics in everyday contexts.

Through senior secondary engineering projects students develop and practise skills of communication, teamwork, decision-making, initiative-taking and self-discipline with increasing confidence and sophistication. In particular, they develop skills in independent and collaborative investigation, employ self-management skills to plan effectively, follow procedures efficiently and work safely, and use collaboration skills to conduct investigations, share research, persuade others and discuss ideas. In considering potential solutions, students also recognise the role of their stakeholders, consider the perspectives of others and gauge how solutions and both opportunities and risk exposure can affect people's lives.

Engineering projects require students to set and monitor performance against goals, take initiative, build their adaptability, communicate effectively, work collaboratively in teams and apply sound and structured decision making.

Ethical Understanding

Through engineering projects there are opportunities for students to develop the capacity to understand and apply ethical and socially responsible principles when collaborating with others to understand problems identify possible solutions, plan, build and improve the chosen solution.

When engaged in systems thinking associated with problems and potential solutions, students have the opportunity to evaluate their findings against the criteria of legality, environmental sustainability, economic viability, health, social and emotional responsibility and social awareness. They can explore ethical issues or limitations associated with using technologies to solve problems.

Engineering projects provide students with the opportunity to consider their own roles and responsibilities as discerning citizens and learn to detect bias and inaccuracies through analysing data and statistics and finding inappropriate methods to make fair comparisons.

Digital technology projects provide students with an understanding of the importance of protecting data, intellectual property and individual privacy in the school environment.

Senior secondary engineering projects the opportunity for students to evaluate the ethics of implementing solutions that may present ethical dilemmas. They critically analyse and apply ethical guidelines in their investigations and solution design. They can learn to develop objective appraisals of options that balance opportunity and risk. They consider the implications of their proposed methods and solutions on others and the environment and use objective information to inform ethical decisions. They learn the importance of ethical behaviour in acknowledging and correcting errors rather than denying findings or evidence.

Intercultural Understanding

Depending on the nature of a particular engineering project, opportunities exist for students to gain an appreciation of the effect of diverse cultural perspectives on the user needs in defining a problem and acceptability of potential technology solutions. Students have the opportunity to learn about the interactions between technologies and different cultural groups and cultural traditions.

Senior secondary engineering projects can assist students to appreciate the contributions of diverse cultures to shaping our community and working in culturally diverse collaborations. They develop awareness that raising some debates within culturally diverse groups requires cultural sensitivity, and they demonstrate open-mindedness to the positions of others. Students also develop an understanding that cultural factors may affect the ways in which project goals may bet set and solutions accepted.

Science

Engineering projects provide students with the opportunity to use and develop their science inquiry skills, as they pose questions, respond to questions and make predictions about objects, materials and nature in the context of the problem that they are trying to solve.

They develop their understanding of the interaction of science and human endeavour while making observations and undertaking measurements about changes to the properties of different materials or changes to the environment in which they are used. Depending on the nature and context of the problem set for the project, students gain an understanding of different areas of science, including biological, chemical, physical, and earth and space.

Students develop their analytical skills while they plan and conduct scientific investigations seeking answers to questions about the nature of the problem. They also consider the use of appropriate materials, processes and equipment to solve the problem, interpret measurements, and compare test results with predictions.

Senior secondary engineering projects provide students with opportunities to build on their learning in Foundation to Year 10 science, particularly science inquiry skills at a more sophisticated level. Engineering projects provide students with real world problems and enable them to apply scientific knowledge and principles at a more advanced level in the fields of Biology, Chemistry, Earth and Environmental Science and Physics. Typically, engineering projects at this level would require students to conduct investigations across a number of scientific disciplines.

Students identify, research and construct questions for investigation in order to understand the problem, identify possible solutions, conduct risk assessments and predict outcomes of the solution options. Students develop the procedures to be followed, materials required to implement the preferred solution and identify the type and amount of primary and secondary data to be collected in order to evaluate the effectiveness of the solution.

Senior secondary engineering projects require students to represent data in meaningful and useful ways, including using appropriate units, symbols and significant figures, to organise and analyse data to identify trends, patterns and relationships, identify sources of uncertainty and techniques to minimise these uncertainties, utilise uncertainty and percentage uncertainty to determine the uncertainty in the result of calculations, and evaluate the impact of measurement uncertainty, synthesise and use evidence to make and justify conclusions.

Mathematics

Engineering projects provide students with the opportunity to use and develop their understanding of numbers and formulae as they apply their understanding of numbers to describe the problem, formulate, plan and test the implementation of potential solutions and communicate their reasoning. Measurement and geometry knowledge and skills are enhanced when they investigate properties of materials associated with the problem and then apply their understanding to define, compare and construct potential solutions. They learn to develop geometric arguments and make meaningful measurements of quantities, choosing appropriate

units of measurement. They build their understanding of the connections between units of measurement and calculate derived measures such as area, speed, force, strength and density.

Statistical and probability skills are developed as students recognise and analyse data and draw inferences from that data. They represent, summarise and interpret data, while undertaking investigations involving the collection and analysis of data about the nature of the problem, investigating potential solutions and evaluating the effectiveness of solutions and potential improvements. They assess likelihood that the potential solutions will solve the problem and make reasoned judgements and decisions, based on evaluation of the data.

Projects would be designed to require application of an increasingly sophisticated ability to critically evaluate risk, probability, error and data concepts, depending on the level of students.

Senior secondary engineering projects provide students the opportunity to apply mathematical knowledge, skills and understanding to solve more sophisticated problems in real world contexts. Students are provided with the opportunity to select the most appropriate techniques to quantify and understand problems, analyse and predict the effectiveness of potential solutions and analyse test results to identify flaws and propose improved solutions. Students develop appropriate models to represent and analyse the problem presented and predict the effectiveness of solutions being considered. They learn to apply mathematical reasoning skills and decision analysis to select the most appropriate solution and communicate their arguments and strategies using appropriate mathematical and statistical language. Students select, use and interpret appropriate mathematical representations to solve problems and make predictions.

As students plan the implementation of the selected solution, they also have the opportunity to apply their knowledge and skills in project planning and scheduling using critical path analysis. Analysis of testing outcomes requires students to interpret mathematical and other information to determine the suitability of their solution and propose improvements.

Depending on the nature of the project, students apply techniques such as financial modelling, network analysis, route and project planning, decision making, and discrete growth and decay, scaling, triangulation and navigation. Other techniques such as calculus and statistical investigation and analysis can be used as a basis for understanding the physical world involving rates of change and modelling physical processes and to describe and analyse phenomena involving uncertainty and variation.

Technologies

The design and technologies learning area of the curriculum, and in particular the Processes and Production Skills strand, encapsulates the fundamental engineering process employed for all engineering projects.

ASK: understand the problem, identify constraints, and technologies available to solve the problem ~ **Investigating and Defining**

IMAGINE: identify possible solutions, estimate solution effectiveness ~ **Generating and Designing**

PLAN: identify how will the solution be implemented, identify technologies and processes to be used ~ **Collaborating and Managing**

CREATE: build the solution and test it ~ **Producing and Implementing**

IMPROVE: valuate test results identify areas for improvement, implement improvements ~ **Evaluating**

Engineering projects therefore provide students with the opportunity to develop and apply design and production skills knowledge and gain experience through the application of the engineering process which is encapsulated within the learning area.

Engineering projects also provide the opportunity for students to develop knowledge and understanding of technologies (materials, systems, components, tools and equipment) within the technology context of the projects and develop an understanding of the relationship between these technologies and society. Engineering projects may focus on how forces can be used to create light, sound, heat, movement, control or support in systems. Projects provide students with the opportunity to develop knowledge and understanding of how forces and the properties of materials affect the behaviour and performance of solutions to solve identified problems.

Engineering projects involving the application of digital technologies provide students with the opportunity to gain knowledge, understanding and skills through which they can safely and ethically exploit the capacity of information systems (people, data, processes, digital systems and their interactions) to solve the identified problem. Engineering projects involving digital technologies can provide students with the opportunity to develop and use computational thinking skills, processes, techniques and digital systems to create solutions to address specific problems.

Students develop knowledge and understanding of the characteristics and properties of a range of materials through producing designed solutions to problems using particular technologies (materials, systems, components, tools and equipment). And by using software, materials, tools and equipment, students work with the concepts of number, geometry, scale, proportion, measurement and volume.

When applied iteratively, through design creation, prototyping, testing, evaluation against requirements, modification and improvement, students creatively explore the benefits and limits of technologies in solving problems.

Senior secondary engineering projects provide students with the opportunity to apply their knowledge and skills of technologies at a more sophisticated level. Typically, senior secondary engineering projects would provide students with the opportunity to explore the application of a range of technologies to problem solving. Students learn that advances in one field of science can influence other areas of science, technology and engineering.

Depending on the nature of the project, students learn the practical use of a variety of research methods involved in the development and modification of design ideas. They can investigate a range of production processes to implement the design and evaluate and improve its effectiveness. Students have the opportunity to critically analyse the factors affecting design and development in order to gain an understanding of practices and processes used by engineers to create solutions to problems. When students analyse, synthesise and report on engineered products and systems they learn about the practical application of a range of technologies, including risks and opportunities from new technologies.

Senior secondary engineering projects enable students to gain an understanding of technology and the significant contribution it has made to contemporary society and how it is used in a wide range of contexts. Students learn that technology may be explained, analysed and predicted using concepts, models and theories that provide a reliable basis for action. Students are provided with the opportunity to develop their investigative skills, including the design and evaluation of prototypes to solve problems, the collection and analysis of data, and the interpretation of evidence. Students develop their ability to use accurate and precise measurement, valid and reliable evidence and scepticism and intellectual rigour to evaluate claims, and their ability to communicate technology understanding, findings, arguments and conclusions using appropriate representations, modes and genres.

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