# iSTEM – Mechatronics and robotics: autonomous car



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## Mechatronics and robotics

Mechatronics and robotics combine electrical, computer and mechanical technologies that lead to new solutions to problems. Automation and autonomous machines are becoming increasingly important for the mechanisation and increased safety of industrial tasks in areas including agriculture, mining, and space exploration.

Mechatronics and robotics are emerging fields, driving high demand for professionals with skills in systems and computational thinking, mathematics, critical thinking and complex problem solving. Advancements in these fields often evolve in parallel with developments in other associated industries including advanced manufacturing, space, computing and cyber security.

Students will develop skills, knowledge and understanding associated with mechatronics and robotics engineering by completing inquiry-based and/or problem-based learning tasks. Students will create machines that are programmable and can carry out a complex series of actions automatically.

### Duration of learning

Indicative time – 25 hours.

### Inquiry question

How can we automate driving?

### Outcomes

A student:

* **ST5-1** designs and develops creative, innovative, and enterprising solutions to a wide range of STEM-based problems
* **ST5-2** demonstrates critical thinking, creativity, problem solving, entrepreneurship and engineering design skills and decision-making techniques in a range of STEM contexts
* **ST5-3** applies engineering design processes to address real-world STEM-based problems
* **ST5-4** works independently and collaboratively to produce practical solutions to real-world scenarios
* **ST5-5** analyses a range of contexts and applies STEM principles and processes
* **ST5-6** selects and safely uses a range of technologies in the development, evaluation, and presentation of solutions to STEM-based problems
* **ST5-7** selects and applies project management strategies when developing and evaluating STEM-based design solutions
* **ST5-8** uses a range of techniques and technologies, to communicate design solutions and technical information for a range of audiences
* **ST5-9** collects, organises, and interprets data sets, using appropriate mathematical and statistical methods to inform and evaluate design decisions
* **ST5-10** analyses and evaluates the impact of STEM on society and describes the scope and pathways into employment.

[iSTEM course document](https://education.nsw.gov.au/teaching-and-learning/curriculum/department-approved-courses/istem#/asset2) © NSW Department of Education for and on behalf of the Crown in the State of New South Wales, 2021.

### Rationale

Australian businesses competing in a global economy will need more employees trained in science, technology, engineering, and mathematics (STEM). Research indicates that 75% of the fastest growing occupations require STEM skills. Global accounting firm PwC (formerly known as PricewaterhouseCoopers) produced a report titled ‘[A smart move](https://www.pwc.com.au/publications/a-smart-move.html)’ where it found that shifting just 1% of the Australian workforce into STEM roles would add $57.4 billion to the gross domestic product (GDP) (net present value over 20 years).

iSTEM is a student-centred Stage 5 elective course that delivers science, technology, engineering, and mathematics education in an interdisciplinary, innovative, and integrated fashion. It was developed in direct response to industry’s urgent demand for young people skilled in science, technology, engineering, and mathematics.

The course was developed in collaboration, and is supported by industry, business, government, and universities, ensuring that students develop future-focused STEM skills. The course has a number of specialised topics, many of which are aligned with NSW State Government priority industries, identified in the [NSW Industry Development Framework](https://www.investment.nsw.gov.au/living-working-and-business/nsw-industry-development-framework/).

iSTEM develops enabling skills and knowledge that increasingly underpin many professions and trades, and the skills of a technologically enabled workforce. It provides students with learning opportunities to develop knowledge and skills to use the most up-to-date technologies including additive manufacturing (3D printing), laser cutters, augmented and virtual reality, drones, smart robotics and automation systems, artificial intelligence (AI) and a range of digital systems.

Students gain and apply knowledge, deepen their understanding, and develop collaborative, creative and critical thinking skills within authentic, real-world contexts. The course uses inquiry, problem and project-based learning approaches to solve problems and produce practical solutions utilising engineering-design processes.

iSTEM is aligned to the concept of ‘[Industry 4.0](https://www.weforum.org/agenda/2019/01/why-companies-should-strive-for-industry-4-0/)’ which refers to a new and emerging phase in the industrial revolution that heavily focuses on interconnectivity, automation, machine learning and real-time data.

iSTEM has been developed to meet the goals of National Federation Reform Council (NFRC) Education Council’s [National STEM School Education Strategy (2016-2026)](https://www.dese.gov.au/education-ministers-meeting/resources/national-stem-school-education-strategy), and supports the NSW Government’s [NSW Industry Development Framework](https://www.investment.nsw.gov.au/living-working-and-business/nsw-industry-development-framework/), the NSW Department of Education’s [Rural and Remote Education Strategy (2021-2024)](https://education.nsw.gov.au/about-us/strategies-and-reports/rural-and-remote-education-strategy-2021-24) and the [High Potential and Gifted Education policy](https://education.nsw.gov.au/policy-library/policies/pd-2004-0051).

### Aim

The aim of the course is to engage and encourage student interest and skills in STEM, appreciate the scope, impact and pathways into STEM careers and learn how to work collaboratively, entrepreneurially, and innovatively to solve real-world problems.

### Purpose and audience

This teaching resource is for teachers delivering or planning to deliver the course. The learning sequence demonstrates how a combination of outcomes can be used to develop teaching and learning activities. It also suggests a range of resources to support teachers when planning and/or teaching the course.

### When and how to use this document

Use this resource when designing learning activities that align with the course outcomes and content. The activities and resources can be used directly or may be adapted based on teacher judgment and knowledge of their students. Consult the course document for further details on sequencing core, elective and specialised topics.

## Learning sequences

This sample learning sequence has been prepared by the NSW Department of Education. It has been developed as a guide for teachers to assist in the development of a teaching and learning program contextualised to an individual school's needs. The scope and depth of the content covered should relate to the school's context, expertise of the teachers delivering the course and the prior knowledge of the students. Plan learning activities that are inclusive and accommodate the needs of all students, in your classroom from the beginning. Some students may require more specific adjustments to allow them to participate on the same basis. Space is provided for adjustments and enhancements that are made to the learning sequence during its implementation, in order to meet the individual needs of students and to allow for differentiation of the iSTEM curriculum. For further advice see [Additional information](#_Additional_information) in this document.

### Weeks 1 and 2

Table 1 – mechatronics and robotics weeks 1 and 2 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 1 – introduction**  **ST5-4, ST5-5, ST5-6**  Students:   * compare and contrast mechatronics engineering and robotics * outline the historical perspectives in the development of mechatronics engineering and robotic systems and how they have impacted society * describe a range of widely known mechatronics and robotics systems. | **Teacher**  Introduce mechatronics and robotics topic.  Present [mechatronics engineering (3:10)](https://www.youtube.com/watch?v=Tj7TcCr8TZk) video.  **Students**  Identify examples of mechatronics systems.  **Teacher**  Outline historical developments contributing to development of mechatronics engineering as a field of study.  Outline early history of robots.  Present [A Brief History of Robotics (10:36)](https://www.youtube.com/watch?v=uoC2ZGRI8a8) video.  Alternatively, present [How Engineering Robots Works (11:01)](https://www.youtube.com/watch?v=uNfUAJBuZ0s) video.  **Students**  Identify examples of robots and/or robotic systems.  **Teacher and students**  Discuss (using identified examples) how to determine the difference between mechatronics and robotics systems.  Define robots and robotic systems.  Define mechatronics systems.  Explore further examples of mechatronics and robotics systems.  **Students**  Create glossary of technical terms (append additional definitions during the topic). | Students can explain the difference between mechatronics and robotics.  Students will have produced a glossary of technical terms and can correctly use these terms in written or verbal responses. | (Add planned adjustments and enhancements, and registration. Ideas for appropriate adjustments and enhancements have been included).  Use closed captions when viewing video to assist understanding and vocabulary building. Pause video to assess student understanding at appropriate points.  Provide paper or digital worksheet with key terms to assist with vocabulary building and knowledge acquisition.  Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  Include multiple opportunities to respond and discuss, for example:   * verbally * individually * partner turn and talk * non-verbally * gesture * response cards. |
| **Challenge accepted**  **ST5-5**  Students:   * describe a range of widely known mechatronics and robotics systems * identify major components of mechatronics and robotics systems * design and build a mechatronics or robotic system to solve a real-world problem. | **Teacher**  Outline 2 basic categories of robot based on modes of operation, emphasising remote-controlled and autonomous as a focus in this unit:   * telerobot * **remote-controlled** * tele-operation * **autonomous** * logic-controlled * behaviour-based.   Outline two categories for **remote-controlled** robots:   * tethered * wireless.   Outline [6 levels (0-5) of self-driving autonomy](https://www.asme.org/topics-resources/content/infographic-defining-the-6-levels-of-self-driving-autonomy) used to describe **autonomous** vehicles.  Set a design challenge to design, build and test a robotic vehicle. Additional context for the challenge could include:   * able to avoid obstacles * move through a maze * traverse given terrain * perform a specific task * search and rescue.   **Students**  Individually or in groups, use engineering design process to define the problem and identify the constraints.  Determine the required capabilities of the robotic vehicle.  Mind map initial thoughts and additional questions.  Write a clear statement describing the problem to be solved. | Students are able to recall the 2 basic categories of robot operation and link the relevant concepts to the context of the challenge.  Students can explain the differences between categories and sub-categories of robot operation.  Students can recognise the different levels of autonomy in real life examples.  Students will be able to identify the level of autonomy of the robotic vehicle they are building as the robot design evolves.  Students will have produced a clear problem definition and a list of relevant constraints applicable to the challenge. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  Message abundancy may be useful when introducing new terminology. The word is spoken, written on the board and represented by visuals.  Provide students with different challenge options and/or negotiate the requirements of the task with appropriate adjustments.  Provide a visual outline of essential stages of planning required for designing and building a robotic vehicle.  Model and scaffold to support students’ understanding of purpose, audience, language features, and structure.  Some students may need support to work in a group.  Provide options for students to share roles if necessary. |
| **Components and control systems**  **ST5-5**  Students:   * identify major components of mechatronics and robotics systems * describe a range of widely known mechatronics and robotics systems. | **Teacher**  Outline the anatomy (or shared common elements) of robots, for example:   * body * chassis * controller (microcontroller or minicomputer) * manipulators * motors * power supply * sensors * actuators (or wheels).   Outline additional specific components of robotic (programmable) vehicle to be designed, for example:   * motor driver * communications link.   Describe the relationship between:   * microcontroller * sensors * actuators * end effectors.   **Students**  Identify components and briefly describe their function and interfaces (pinouts).  Determine what types of components may be used in the design challenge.  **Teacher and students**  Evaluate components available for the design challenge. | Students will be able to identify key components of robots using correct terminology.  Students can recognise the pinout or marking for various components.  Students can describe the difference and the relationship between actuators, end effectors, microcontrollers and sensors. The relationship can be shown with diagrams or words. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  Provide options for students to share roles if necessary. |
| **Weekly reflection** | **Teacher**  Monitor the progress of student reflections.  **Students**  Identify tasks undertaken, new knowledge, understanding or skills. | Students answer reflective questions, for example:   * What did I learn about this week? | Procedural recount can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 2 – Portable power**  **ST5-5**  Students:   * identify major components of mechatronics and robotics systems * outline power sources used in mechatronics and robotics systems * describe engineering concepts * use fundamental techniques in arithmetic, measurement, and geometry to complete tasks. | **Teacher**  Outline power supplies used in various robotics systems.  Explain the concept of power-to-weight ratio (PWR or specific power) with particular reference to electric powered vehicles, for example:   * batteries * electric motors * fuel cells * photovoltaics (solar panels).   Describe the characteristics and capacities of a range of disposable batteries and rechargeable batteries.  **Students**  Record the weight of various types and capacities of batteries.  Determine the most suitable battery (type and capacity) for the project.  Identify available batteries for the project and assess the optimal configuration to minimise battery payload and maximise power output (PWR).  **Teacher and students**  Discuss the advantages and disadvantages of different types of batteries.  Calculate the operating time (discharging time) for a range of battery sizes (or capacity) and loads (discharge) according to:  Investigate factors that may impact the expected output, operating time and efficiency. | Students can identify various power sources used in robotics projects.  Students are able to suggest suitable power supply options for a given scenario.  Students can outline benefits and disadvantages of using either disposable or rechargeable batteries.  Students can suggest the best configuration of batteries based on (their measurements of) the combined weight of batteries and the required output.  Students know how to calculate estimates of the battery operating time (approximate discharge time) based on expected loads and battery capacity. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice.  Modelling equipment used to take measurements will assist in skill building.  Assist with measurement recording and creation of appropriate tables. |
| **Learning to code a microcontroller**  **ST5-4, ST5-5, ST5-6, ST5-8**  Students:   * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects. | **Teacher**  Introduce microcontroller and other hardware to be used and explain safety issues.  Demonstrate how the coding environment operates and how to upload code to the microcontroller (or robotics platform).  **Students**  Learn to use selected coding environment to program microcontroller to perform some tasks, for example:   * turn LED on/off * controlling motor * reading sensor values.   **Teacher**  Review (or explain) programming concepts, including:   * control structures * sequence * selection (branching) * repetition (iteration) * relevant data types * text * numbers * boolean * functions (as necessary). | Students can identify key hardware elements.  Students can articulate safety requirements of each piece of technology to be used.  Students can identify key features of a program written in the selected general-purpose coding language.  Students can enter instructions or code into the coding environment and successfully upload it onto the microcontroller.  Students can demonstrate success with properly functioning code as intended by the set task.  If the code is not functioning properly, they are working on debugging syntax errors.  If the code is functioning, but not as intended by the task, they correct the code’s logic errors. | During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice and revision.  Provide written and/or visual scaffold for identification of key elements and any safety requirements.  Provide scaffolds and templates of documents based on student needs and the desired level of student independence. |
| **Online simulations**  **ST5-4, ST5-5, ST5-6, ST5-8**  Students:   * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects. | **Teacher**  Introduce online coding environment, for example:   * Tinkercad * Makecode * Wokwi   **Students**  Use online coding environment to design and test circuits, for example, using Tinkercad to test microbit python coding. | Students can successfully use virtual coding environment to design and test circuits which use virtual components like the proposed robotic vehicle (car).  Code created by students in the online environment can be transferred to the physical microcontroller.  Students can demonstrate success with properly functioning code as intended by the set task. | Prepare and save circuits in virtual environments to help scaffold complex circuits. |
| **Weekly reflection** | **Teacher**  Monitor the progress of student reflections.  **Students**  Complete weekly reflection evaluating new knowledge, understanding or skills in relation to previous knowledge. | Students making judgments about what has happened and what they still need to understand. | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 3 and 4

**Note:** Servo motors (servos) can be controlled directly from the microcontroller but need to draw their power from a reliable external supply (not the microcontroller). If connecting a single servo directly to the microprocessor, check the current draw of the servo under load to ensure it does not exceed the microprocessor’s limits. Some ‘robotics’ boards provide options for controlling motors and/or servos.

Table 2 – Mechatronics and robotics weeks 3 and 4 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 3 – Controlling motors**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * identify major components of mechatronics and robotics systems * construct a mechatronics or robotics system using electrical and mechanical components * use a range of mechanical devices that produce motion * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **Teacher**  Outline available motor options for making the robotic vehicle move, for example:   * DC motors * gearmotors * servomotors (servo) * stepper motors.   Demonstrate the basic operation of a DC motor with a DC power source, including varying the voltage (within safe limits of operating voltage).  State the power required to turn example motor.  Explain the issue that motors (and servos) draw more current (or require more power) than microcontrollers can supply.  Describe the risks of connecting a motor (or servo) directly to a microcontroller.  **Students**  Identify aspects of a DC motor that are needed to be controlled, for example:   * speed * direction * torque.   **Teacher**  Outline the purpose of a motor driver board (or motor controller or servo control board).  Introduce available motor driver board and gearmotor.  Demonstrate the connections and setup of the motor driver (or motor controller) board and gearmotor.  Demonstrate code for controlling speed and direction of gearmotor.  **Students**  Connect the motor driver board, gearmotor and power source onto a test platform.  Create and/or upload test code to demonstrate control of speed and direction of gearmotor.  **Extension (optional)**  Explain considerations when selecting motors and motor driver components, for example:   * load * power supply voltage * current draw * current limit * power consumption. | Students can identify features of a DC motor.  Students can explain that speed and direction of a motor can be used to control a device. | Provide visual and/or multimedia examples and check understanding of concepts.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Pulse-Width Modulation (PWM)**  **ST5-5**  Students:   * use a range of mechanical devices that produce motion. | **Teacher**  Explain how Pulse-Width Modulation (PWM) works and how it can be used to control the speed of a motor (gearmotor).  Demonstrate the **change in** connections and setup of the motor driver (or motor controller) board and gearmotor highlighting input pins that have changed.  Demonstrate code for controlling speed and direction of gearmotor using PWM.  **Students**  Connect the motor driver board, gearmotor and power source onto a test platform.  Create and/or upload test code to demonstrate control of speed and direction of gearmotor. | Students can create or upload test code to demonstrate control of speed and direction of a gearmotor. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Controlling servo motors (servos)**  **ST5-5**  Students:   * identify major components of mechatronics and robotics systems * design, simulate and refine mechatronics and robotics systems. | **Teacher**  Describe the common types of servos and their external parts/connections, for example:   * positional rotation (standard rotary) * continuous rotation * linear servo * plastic gear * metal gear * horns.   Identify options for controlling one or several servos.  Demonstrate setting up the microprocessor and servo controller board as test platform.  Connect the servo to the servo controller board (or microprocessor) and its power rail.  Demonstrate code for controlling speed and direction of servo using PWM.  **Students**  Connect the servo with a horn to a servo controller board (mounted on a test platform) and connect a power source.  Create and/or upload test code to demonstrate control of direction and speed of servo.  **Extension (optional)**  Explore options for controlling multiple servos from a single microprocessor, for example:   * servo controller boards * shields.   Brainstorm other uses for servos on the robotic vehicle. | Students can identify key features of a program written in the selected coding language.  Students can enter instructions or code into the coding environment and successfully upload it onto the microcontroller.  Students can demonstrate success with properly functioning code as intended by the set task. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  Explicitly demonstrate the correct use and connection of components.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Weekly reflection** | **Teacher**  Monitor the progress of student reflections.  **Students**  Complete weekly reflection identifying tasks undertaken, new knowledge, understanding or skills. | Students answer reflective questions, for example:   * ‘What did I learn about this week?’ | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 4 – Steering options**  **ST5-5**  Students:   * identify major components of mechatronics and robotics systems. | **Teacher**  Outline [common steering architectures (1:35)](https://www.youtube.com/watch?v=F3G0sUz3_Jw) for robotic (cars) vehicles, for example:   * differential-speed steering (skid steering) * articulated steering * axle * frame * Ackerman steering (coordinated) * rack and pinion * independent (explicit) steering.   **Students**  Sketch diagrams of steering types.  Rank the steering types in order of:   * manoeuvrability * complexity * number of joints for steering.   **Teacher and students**  Explore how to determine turning radius for each steering type.  Study examples of steering mechanisms in robotic vehicles. | Students can recognise the common steering options for robotic vehicles either from diagrams or physical examples.  Students will have produced correct sketches of the different types of steering architectures.  Students know how to calculate the turning circle of their robotic vehicle.  Students will be able to suggest a suitable steering option based on the available components and/or required turning radius.  Students actively participate in classroom discussion. | Use closed captions when viewing the video to assist understanding and vocabulary building. |
| **Brainstorming chassis**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * design and build a mechatronics or robotic system to solve a real-world problem. | **Teacher**  Introduce materials, resources and fabrication tools.  Set the parameters of the task, including available materials, size constraints and allowed time.  **Students**  Measure and record dimensions of hardware components, including mass.  Identify and assess known relevant constraints, which may include:   * construction materials * layout of components * steering mechanism * power requirements/power sources * mass.   **Teacher**  Define divergent thinking.  Explain the importance of thinking about ‘the possible’ before thinking about limitations and constraints.  **Review strategies to guide and promote good** [brainstorming](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/542#.Y_0rq7ZxLDo.link) **practice, for example:**   * **record all ideas** * **thinking activities like trigger cards** * **consider diverse perspectives.**   **Students**  Collect and organise ideas. Evaluate options and select the most appropriate chassis design for production. | Students will have accurately collected measurements of components and produced a list of required dimensions.  Students will then use this information to inform their decision-making and recorded any brainstorming and design thinking processes (this may also include annotations on sketches). | During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  Consider student needs and alternative options when using thinking activities and graphical organisers for brainstorming.  Model how to complete whatever graphic organiser is used, as students may not be familiar with these learning tools.  Include multiple opportunities to respond, for example:   * verbally * individually * partner turn and talk * non-verbally * gesture * response cards. |
| **Designing chassis**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * design and build a mechatronics or robotic system to solve a real-world problem. | **Teacher**  Demonstrate how to use suitable CAD software (or traditional drawing techniques) to communicate accurate design information.  Present examples of chassis (or designs) and design choices.  **Students**  Annotate features of chassis design including dimensions.  Generate designs using CAD software (or traditional drawing techniques).  Evaluate designs and modify as necessary. | Students produced technical drawings of their chassis designs.  Multiple versions of designs with notes about modifications indicates students’ iterative design processes. | During practical learning activities, use and emphasise target language required and encourage students to use this language in context. |
| **Weekly reflection** | **Teacher**  Monitor the progress of student reflections.  **Students**  Complete weekly reflection evaluating new knowledge, understanding or skills in relation to previous knowledge. | Students will demonstrate the impact of these learning events or activities by making judgments about what has happened and what they still need to understand. | Modelling of the reflective process may assist with the metacognitive aspects of this task. |

### Weeks 5 and 6

Table 3 – Mechatronics and robotics weeks 5 and 6 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 5 –** **Build chassis (assign minimum 2 days)**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * design and build a mechatronics or robotic system to solve a real-world problem. | **Teacher**  Review risk assessments with students for required equipment.  Organise and facilitate safe fabrication processes, which may include:   * marking out * cutting and drilling * 3D printing * laser cutting.   **Students**  Continue to iterate design modifications in CAD if required.  Build prototype and test for rigidity and durability.  Test fit components and ensure mounting points positioned to secure components.  Test alignment of motors and/or axles.  Evaluate and modify as necessary. | Students demonstrate capacity to use available materials to produce a chassis capable of mounting chosen steering options. | During practical learning activities, use and emphasise target language required and encourage students to use this language in context. |
| **Install base components**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * design and build a mechatronics or robotic system to solve a real-world problem. | **Teacher**  Demonstrate installation of components onto final chassis, for example:   * motors (and/or axles) * microprocessor * motor controller * battery pack.   **Students**  Complete installation of base components onto chassis.  Check alignment of wheels.  **Teacher**  Provide sample test code.  **Students**  Run sample code to test connectivity of components and basic function when powered on. | Students successfully run sample code to test connectivity of components and basic function of chassis and components. | Explicitly demonstrate the correct use and connection of components. |
| **Functionality testing**  **ST5-4, ST5-6**  Students:   * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * design, simulate and refine mechatronics and robotics systems. | **Teacher**  Demonstrate various test codes to determine practicality of chassis for movement.  **Student**  Run sample code to test chassis basic function and movement. | Students can run various test codes to determine viability of chassis for movement. | (Add adjustments, enhancements, and registration) |
| **Weekly reflection** | **Teacher**  Monitor the progress of student reflections.  **Students**  Complete weekly reflection identifying tasks undertaken, new knowledge, understanding or skills. | Students answer reflective questions, for example:   * What did I learn about this week? | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 6 – Communication links**  **ST5-4, ST5-6**  Students:   * explore wireless communications technologies to control mechatronics and robotics system. | **Teacher**  Outline types and properties of wireless communication used in mechatronics and robotics systems, for example:   * infrared (IR) * Bluetooth * Wi-Fi * cellular (4G and/or 5G) * radio * GPS   **Student**  Arrange different types of communication mediums from shortest range to longest range.  Identify infrastructure required to support each communication type.  **Teacher and students**  Identify issues that could occur with each type of communication technology.  Discuss the viability of each communication type within the context of the challenge.  **Extension (optional)**  Explore protocols for each communication type studied. | Students can describe and distinguish between various types of wireless communication technologies.  Students can correctly arrange wireless technologies according to range of signal and common uses (related to bandwidth capacity).  Students can identify advantages and disadvantages of various wireless technologies. | (Add adjustments, enhancements, and registration) |
| **Bluetooth**  **ST5-4, ST5-6**  Students:   * explore wireless communications technologies to control mechatronics and robotics system * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **Teacher**  Outline the function and pinout of a Bluetooth module.  Demonstrate how to connect a Bluetooth module to microcontroller.  **Student**  Follow procedures to connect Bluetooth module to microcontroller.  **Teacher**  Demonstrate and explain the code needed to communicate with the Bluetooth module.  Demonstrate the code in operation sending commands to untethered microcontroller via Bluetooth.  **Students**  Upload code to microcontroller and test by sending commands to an untethered microcontroller via Bluetooth.  **Teacher and students**  Discuss findings from activity, for example:   * What was the range of the Bluetooth signal? * How secure is the communication link? | Students can follow procedures to connect and use a Bluetooth module.  Students can enter instructions or code into the coding environment and successfully upload it onto the microcontroller.  Students can demonstrate success with properly functioning code as intended by the set task. | Explicitly demonstrate the correct use and connection of components.  Provide worksheet with key terms to assist with vocabulary building and knowledge acquisition.  Provide worksheet with diagrams or images to allow students to follow, after teacher demonstration. |
| **Install Bluetooth**  **ST5-4, ST5-6**  Students:   * explore wireless communications technologies to control mechatronics and robotics system * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **Teacher**  Demonstrate installation of Bluetooth onto chassis.  **Students**  Complete installation of Bluetooth onto chassis.  Confirm Bluetooth connectivity with untethered microcontroller to provide remote control of motors and/or servos and additional components.  **Teacher**  Provide sample test code.  **Students**  Run sample code to test remote control of components on robotic vehicle when powered on.  **Extension (optional)**  Investigate creating mobile apps which can connect to the Bluetooth module to send commands to robotic platform (and receive feedback). | Students can follow procedures to connect and use a Bluetooth module.  Students can enter instructions or code into the coding environment and successfully upload it onto the microcontroller.  Students can demonstrate success with properly functioning code as intended by the set task. | (Add adjustments, enhancements, and registration) |
| **Weekly reflection** | **Teacher**  Monitor the progress of student reflections.  **Students**  Complete weekly reflection evaluating new knowledge, understanding or skills in relation to previous knowledge. | Students answer reflective questions, for example:   * What did I learn about coding this week? * How is this learning activity like the operation of sensors in normal cars? | (Add adjustments and registration) |

### Weeks 7 and 8

**Note:** In Week 8 (and again in Week 9) there is opportunity to explore computer vision. Computer vision (live image capture and/or streaming), requires processing power not normally available with microcontrollers. New (affordable) camera technology can achieve this to some degree, but schools may not have access to this. Demonstrations for computer vision may also be carried out on computer devices.

Table 4 – Mechatronics and robotics weeks 7 and 8 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 7 – From telerobot to autonomous robot**  **ST5-5**  Students:   * design and build a mechatronics or robotic system to solve a real-world problem * work individually and collaboratively to apply an engineering design process to complete real-world problems and challenges. | **Teacher and students**  Review current capabilities of robotic vehicle, for example:   * speed * range * manoeuvrability.   **Teacher**  Emphasise lack of:   * autonomy (without external intervention) * awareness (of surrounding environment).   Outline control systems used in the robotics, for example:   * open loop * closed loop * sensor feedback * navigation.   **Teacher and students**  Access [The Secret Technology Helping Driverless Cars: Remote Control (3:38)](https://www.youtube.com/watch?v=9sgetWQGYxY) and discuss possible outcomes of driverless cars, both remote controlled and autonomous.  Discuss general strategies to enable feedback (closed loop) control. | Students actively participate in classroom discussion.  Students can describe the current capabilities and assess known limitations of their robotic vehicle.  Students can demonstrate that they understand the difference between a telerobot and an autonomous robot using their robotic vehicle as an example. | Include multiple opportunities to respond, for example:   * verbally * individually * partner turn and talk * non-verbally * gesture * response cards.   Review key concepts and vocabulary before viewing video. Use closed captions and provide the transcript. Pause video to assess student understanding at appropriate points. |
| **Sensors and output devices**  **ST5-5**  Students:   * describe the operation of sensors * describe the operation of output devices. | **Teacher**  Outline the operation of various sensors, for example:   * magnetometer * gyroscope * accelerometer.   Outline the operation of various output devices, for example:   * actuators * end effectors * grippers * displays * lights.   **Student**  Identify sensors and output devices and their functions.  **Teacher and students**  Explore a range of sensors and output devices to determine potential applicability to various situations related to the challenge. | Students will be able to recall the name, type and function of a variety of sensors.  Students are able to identify a sensor by locating distinguishing labels and codes on the sensor board.  Students can identify various output devices by appearance and recall the name, type and function.  Student can distinguish between the role of sensors and output devices.  Students will be able to suggest potential sensors and explain what functionality it will add to the robotic vehicle. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Code for ultrasonic sensors**  **ST5-4, ST5-6**  Students:   * describe the operation of sensors * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * design, simulate and refine mechatronics and robotics systems. | **Teacher**  Outline the function of an ultrasonic sensor.  Demonstrate how to connect ultrasonic sensor to microcontroller.  **Student**  Follow procedures to connect ultrasonic sensor to microcontroller.  **Teacher**  Explain the sequence of events that occurs when an ultrasonic sensor is switched on.  Demonstrate and explain the code needed to measure the distance of an object in front of the sensor.  Demonstrate the code in operation.  **Students**  Upload code to microcontroller and test by placing objects in front of sensor at different distances.  **Teacher and students**  Discuss findings from activity, for example:   * How accurate was the sensor? * What was the field of view? | Students can follow procedures to connect and use an ultrasonic sensor.  Students can enter instructions or code into the coding environment and successfully upload it onto the microcontroller.  Students can demonstrate success with properly functioning code as intended by the set task. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice.  Provide worksheet with key terms to assist with vocabulary building and knowledge acquisition.  Provide worksheet with diagrams or images to allow students to follow, after teacher demonstration. |
| **Install sensor**  **ST5-4, ST5-6**  Students:   * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * design, simulate and refine mechatronics and robotics systems. | **Teacher**  Demonstrate installation of ultrasonic sensor components onto chassis.  **Students**  Complete installation of sensor on chassis.  **Teacher**  Provide sample test code.  **Students**  Run sample code to test connectivity of components and basic function when powered on. | Students can follow procedures to install ultrasonic sensor onto chassis.  Students can enter instructions or code into the coding environment and successfully upload it onto the microcontroller.  Students can demonstrate success with properly functioning code as intended by the set task. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context. |
| **Weekly reflection** | **Teacher**  Monitor the progress of student reflections.  **Students**  Complete weekly reflection identifying tasks undertaken, new knowledge, understanding or skills. | Students answer reflective questions, for example:   * What did I learn about this week? | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 8 – Install additional sensors**  **ST5-4, ST5-6**  Students:   * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **Teacher**  Demonstrate installation of additional sensor components onto chassis, for example:   * line following * magnetometer * accelerometer * time-of-flight (ToF).   **Students**  Complete installation of sensors on chassis.  Check connectivity of components with microcontroller.  **Teacher**  Provide sample test code.  **Students**  Run sample code to test connectivity of components and basic function when powered on. | Students can follow procedures to connect and use selected sensors.  Students can enter instructions or code into the coding environment and successfully upload it onto the microcontroller.  Students can demonstrate success with properly functioning code as intended by the set task. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Testing installation**  **ST5-4, ST5-6**  Students:   * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects. | **Teacher**  Review conditions the robotic vehicle will operate under and guide students in developing an algorithm to measure, calculate and respond to data inputs from sensor components. This will also include the rate of measurements (for example measurements per second) and the required precision of the sensor data.  Outline options for testing functionality of sensors, for example:   * simulating environmental conditions * range of acceptable values * sensitivity * signal to noise ratio * testing under environmental conditions.   **Student**  Continue with tests to confirm all sensors and control systems are functioning correctly. | Students can collaboratively devise test condition parameters to test the operation of their robotic vehicle against.  Students can demonstrate how their robotic vehicle performs under a range of pre-set conditions.  Students will be able to evaluate any data readings (values) from sensors and physical observations (including measurements) to determine if the robotic vehicle is operating as expected and within accepted ranges of performance. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Image sensors**  **ST5-4, ST5-6**  Students:   * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **Teacher**  Outline types of image sensors and how they function, for example:   * IR * NOIR * PIR * light intensity * camera.   **Teacher and students**  Discuss how image sensors could be used by mechatronic and robotics systems to provide input (sense their environment) to respond and/or automate processes.  **Teacher**  Demonstrate how to setup camera modules (or even webcams) to capture single images.  **Demonstrate how to setup camera** modules to **capture video streams.** | Students will be able to recall the name, type and function of a variety of image sensors.  Students can identify various image sensors by appearance and recall the name, type and function.  Student can distinguish between the role of various image sensors.  Students will be able to suggest potential image sensors and explain what functionality it will add to the robotic vehicle. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand technical and context specific terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Weekly reflection** | **Teacher**  Monitor the progress of student reflections.  **Students**  Complete weekly reflection evaluating new knowledge, understanding or skills in relation to previous knowledge. | Students will demonstrate the impact of these learning events or activities by making judgments about what has happened and what they still need to understand. | Modelling of the reflective process may assist with the metacognitive aspects of this task. |

### Weeks 9 and 10

**Note:** Week 9 provides an opportunity to explore transmitting video streams from the robot to a remote user and investigating Wi-Fi to both enable the video function and extend the range of the robot. Alternatively, teachers could decide to use this lesson time to further investigate the selection of other sensors outlined previously.

Table 5 – Mechatronics and robotics weeks 9 and 10 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 9 – Wi-Fi Communication**  **ST5-4, ST5-5, ST5-6, ST5-8**  Students:   * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **Teacher**  Outline functions and pinout of a Wi-Fi module.  Demonstrate how to connect a Wi-Fi module to microcontroller (or directly to microcontroller if Wi-Fi enabled).  **Student**  Follow procedures to connect to microcontroller via Wi-Fi.  **Teacher**  Demonstrate and explain the code needed to communicate with the Wi-Fi module.  Demonstrate the code in operation sending commands to untethered microcontroller via Wi-Fi.  **Students**  Upload code to microcontroller and test by sending commands to an untethered microcontroller via Wi-Fi.  **Teacher and students**  Discuss findings from activity, for example:   * What was the range of the Wi-Fi signal? * Is Wi-Fi communication more secure? | Students can follow procedures to connect and/or use a Wi-Fi (or radio) module.  Students can enter instructions or code into the coding environment and successfully upload it onto the microcontroller.  Students can demonstrate success with properly functioning code as intended. | Provide visual and/or multimedia examples and check understanding of concepts.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Install Wi-Fi**  **ST5-4, ST5-5, ST5-6, ST5-8**  Students:   * explore wireless communications technologies to control mechatronics and robotics system * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **Teacher**  Demonstrate installation of Wi-Fi module onto chassis.  **Students**  Complete installation of Wi-Fi onto chassis.  Confirm Wi-Fi connectivity with untethered microcontroller to provide remote control of motors and/or servos and additional components.  **Teacher**  Provide sample test code.  **Students**  Run sample code to test remote control of components on robotic vehicle when powered on.  **Extension (optional)**  Investigate creating mobile apps which can connect to the Wi-Fi module to send commands to robotic platform (and receive feedback). | Students can follow procedures to connect and/or use a Wi-Fi (or radio) module.  Students can enter instructions or code into the coding environment and successfully upload it onto the microcontroller.  Students can demonstrate success with properly functioning code that allows remote-control of all components on the robot vehicle. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Video stream**  **ST5-4, ST5-6**  Students:   * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. * describe emerging technologies related to mechatronics and robotics engineering * explain the effects of mechatronics and robotics innovation on current and future careers. | **Teacher**  Demonstrate how live video stream can enhance awareness of immediate environment when controlling the robotic vehicle remotely, for example:   * avoiding obstacles * avoiding steep declines * object recognition.   **Teacher and students**  Investigate computer vision and its application in robotic systems.  Investigate technical requirements to enable computer vision and object recognition with artificial intelligence and machine learning.  **Extension (optional)**  Connect camera module to microcontroller/microcomputer on robotic vehicle (or on a test platform) and setup for still image capture and video stream transmission. | Students can outline some technical requirements for transmitting a video stream from a digital camera to a receiver.  Students can outline some applications of computer vision in robotic systems. | Provide visual and/or multimedia examples and check understanding of concepts.  Ensure all students understand both technical and culturally-based terms.  During practical learning activities, use and emphasise target language required and encourage students to use this language in context.  The language required should be taught explicitly with opportunities for guided practice. |
| **Weekly reflection** | **Students**  Complete weekly reflection by identifying and evaluating new knowledge or skills considering previous knowledge. | Students answer reflective questions, for example:   * What did I learn about communication this week? | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 10 – Machine learning (ML) and artificial intelligence (AI)**  **ST5-4, ST5-5, ST5-6**  Students:   * describe emerging technologies related to mechatronics and robotics engineering * outline machine learning and artificial intelligence uses in mechatronics and robotics systems * explain the effects of mechatronics and robotics innovation on current and future careers. | **Teacher**  Outline how ML is a subset of artificial intelligence and identify some applications of machine learning.  Present [Watch this AI Robot Pick Peppers With A Tiny Saw (2:07)](https://www.youtube.com/watch?v=5chk9Sory88) and [Traptic Farming Robots 2021 (1:48)](https://www.youtube.com/watch?v=ZPmsvnouJ9w).  Explain how ML can be applied to image recognition tasks used in fruit picking.  **Teacher and students**  Discuss the use of mechatronics and robotics to solve agricultural problems.  Evaluate the source of information in these videos and compare the way information is presented.  **Teacher**  Present [How Robots Are Changing The Farming Industry (2:18)](https://www.youtube.com/watch?v=4qrlFse5I1U).  **Teacher and students**  Evaluate the statement in the video that “robots will save farmers thousands of dollars”.  Identify further information that may be needed. | Students can describe some emerging technologies related to robotics.  Students can identify uses for AI and ML in robotics and mechatronics. | Review key concepts and vocabulary before viewing video. Use closed captions and provide the transcript. Pause video to assess student understanding at appropriate points.  Provide worksheet with key terms to assist with vocabulary building and knowledge acquisition. |
| **Careers**  **ST5-4, ST5-5, ST5-6**  Students:   * develop an understanding of the mechatronics and robotics engineering industry * investigate the nature of work and pathways into industries that support mechatronics, robotics, and related careers * engage in industry career development opportunities to gain a deeper knowledge of professions that utilise mechatronics and robotics, develop skills, knowledge and understanding of authentic, real-world problem-solving. | **Teacher**  Present the [Day at Work: Robotics Engineer (3:21)](https://www.youtube.com/watch?v=7trO3sQzmf8) video.  Present the [Career Spotlight: Mechatronics Engineer (2:57)](https://www.youtube.com/watch?v=jQb9-xEDWK4) video.  **Teacher and students**  Explore the career profile for [Kanchana (2:51)](https://youtu.be/6QzkkNziwvM) using the video linked. **Outline the pathway Kanchana took to work in** power engineering.  **Teacher**  Present students with [STELR Women in STEM](https://stelr.org.au/womeninstem/) website link.  **Students**  Explore the STELR Women in STEM website.  Explore 2 other career profiles of personal interest.  Investigate the nature of work undertaken and the pathways into professions which utilise STEM skills. | Students will be able to outline some of the many STEM career pathways associated with the mechatronics and robotics industry.  Students undergo self-reflection in relation to a career they would like to possibly pursue and can describe pathways to different STEM careers.  Students identify the importance of diversity, for example:   * mindset * culture * experience * training * multilingual. | Review key concepts and vocabulary before viewing video. Use closed captions when viewing video to assist understanding and vocabulary building. Pause video to assess student understanding at appropriate points.  Provide worksheet with key terms to assist with vocabulary building and knowledge acquisition. |
| **Present and test final solution**  **ST5-2, ST5-3, ST5-4, ST5-5, ST5-6, ST5-8, ST5-9**  Students:   * work individually and collaboratively to apply an engineering design process to complete real-world problems and challenges * demonstrate innovation and entrepreneurial activity and communicate solutions to problems involving mechatronics or robotics. | **Teacher**  Organise test field for final testing.  **Students**  Test the continued operation of the robot under normal (or expected) operating conditions.  Critically reflect and evaluate performance of the final design solution against the success criteria.  Demonstrate compliance with the identified requirements and success criteria.  **Teacher and students**  Evaluate the benefits of using information communication technologies to solve problems of automation. | Students demonstrate critical thinking, creativity, problem-solving, entrepreneurship, and engineering design skills in presenting their prototypes and/or final designs. | Students may not be able to present information verbally. An electronic method for the whole class to share presentations may be utilised, for example:   * PowerPoints that have voice recording * PowerPoints that have comprehensive notes and no voice recording.   Adjust learning activities based on student individual learning plans. |
| **Weekly reflection** | **Teacher**  Assess the progress of student reflections.  **Students**  Complete weekly reflection evaluating new knowledge, understanding or skills in relation to previous knowledge. | Students will demonstrate the impact of these learning events or activities by making judgments about what has happened and what they still need to understand. | Modelling of the reflective process may assist with the metacognitive aspects of this task. |

## Additional information

**Resource evaluation and support:** Please complete the following [feedback form](https://forms.office.com/Pages/ResponsePage.aspx?id=muagBYpBwUecJZOHJhv5kbKo2q_ZUXlHndJMnh2Wd8NUOUk0VTIzUDVVSlVFQVM5MkdOMkJGTjVKNCQlQCN0PWcu) to help us improve our resources and support.

The information below can be used to support teachers when using this teaching resource for iSTEM.

### Assessment for learning

Possible formative assessment strategies that could be included:

* Learning intentions and success criteria assist educators to articulate the purpose of a learning task to make judgements about the quality of student learning. These help students focus on the task or activity taking place and what they are learning and provide a framework for reflection and feedback. [Online tools](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/622) can assist implementation of this formative assessment strategy.
* Eliciting evidence strategies allow teachers to determine the next steps in learning and assist teachers in evaluating the impact of teaching and learning activities. Strategies that may be added to a learning sequence to elicit evidence include all student response systems, [exit tickets](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/543), mini whiteboards (actual or [digital](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/575)), [hinge questions](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/560), [Kahoot](https://app.education.nsw.gov.au/digital-learning-selector/LearningTool/Card/621), [Socrative](https://app.education.nsw.gov.au/digital-learning-selector/LearningTool/Card/587), or quick quizzes to ensure that individual student progress can be monitored and the lesson sequence adjusted based on formative data collected.
* Feedback is designed to close the gap between current and desired performance by informing teacher and student behaviour (AITSL 2017). AITSL provides a [factsheet to support evidence-based feedback](https://www.aitsl.edu.au/teach/improve-practice/feedback#:~:text=FEEDBACK-,Factsheet,-A%20quick%20guide).
* [Peer feedback](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/549) is a structured process where students evaluate the work of their peers by providing valuable feedback in relation to learning intentions and success criteria. It can be supported by [online tools](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Browser?cache_id=1d29b).
* Self-regulated learning opportunities assist students in taking ownership of their own learning. A variety of strategies can be employed and some examples include reflection tasks, [Think-Pair-Share](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/645), [KWLH charts](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/562), [learning portfolios](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/583) and [learning logs](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/583).

The primary role of assessment is to establish where individuals are in their learning so that teaching can be differentiated and further learning progress can be monitored over time.

Feedback that focuses on improving tasks, processes and student self-regulation is the most effective. Students engaging with feedback can take many forms including formal, informal, formative, summative, interactive, demonstrable, visual, written, verbal and non-verbal.

[What works best update 2020](https://education.nsw.gov.au/about-us/educational-data/cese/publications/research-reports/what-works-best-2020-update) (CESE 2020a)

### Differentiation

Differentiated learning can be enabled by differentiating the teaching approach to content, process, product and the learning environment. For more information on differentiation go to [Differentiating learning](https://education.nsw.gov.au/teaching-and-learning/professional-learning/teacher-quality-and-accreditation/strong-start-great-teachers/refining-practice/differentiating-learning) and [Differentiation](https://education.nsw.gov.au/campaigns/inclusive-practice-hub/primary-school/teaching-strategies/differentiation).

When using these resources in the classroom, it is important for teachers to consider the needs of all students in their class, including:

* **Aboriginal and Torres Strait Islander students**. Targeted [strategies](https://education.nsw.gov.au/teaching-and-learning/aec/aboriginal-education-in-nsw-public-schools) can be used to achieve outcomes for Aboriginal students in K-12 and increase knowledge and understanding of Aboriginal histories and cultures. Teachers should utilise students’ Personalised Learning Pathways to support individual student needs and goals.
* **EAL/D learners**. EAL/D learners will require explicit English language support and scaffolding, informed by the [EAL/D enhanced teaching and learning cycle](https://education.nsw.gov.au/teaching-and-learning/curriculum/literacy-and-numeracy/resources-for-schools/eald/enhanced-teaching-and-learning-cycle) and the student’s phase on the [EAL/D Learning Progression](https://education.nsw.gov.au/teaching-and-learning/curriculum/multicultural-education/english-as-an-additional-language-or-dialect/planning-eald-support/english-language-proficiency). In addition, teachers can access information about [supporting EAL/D learners](https://education.nsw.gov.au/teaching-and-learning/curriculum/multicultural-education/english-as-an-additional-language-or-dialect/planning-eald-support/english-language-proficiency) and [literacy and numeracy support specific to EAL/D learners](https://education.nsw.gov.au/teaching-and-learning/curriculum/literacy-and-numeracy/resources-for-schools/eald).
* **Students with additional learning needs**. Learning adjustments enable students with disability and additional learning and support needs to access syllabus outcomes and content on the same basis as their peers. Teachers can use a range of [adjustments](https://education.nsw.gov.au/teaching-and-learning/disability-learning-and-support/personalised-support-for-learning/adjustments-to-teaching-and-learning) to ensure a personalised approach to student learning. In addition, the [Universal Design for Learning planning tool](https://education.nsw.gov.au/teaching-and-learning/learning-from-home/teaching-at-home/teaching-and-learning-resources/universal-design-for-learning) can be used to support the diverse learning needs of students using inclusive teaching and learning strategies. Subject specific curriculum considerations can be found on the [Inclusive Practice hub](https://education.nsw.gov.au/campaigns/inclusive-practice-hub/primary-school/teaching-strategies/differentiation).
* **High potential and gifted learners**. [Assessing and identifying high potential and gifted learners](https://education.nsw.gov.au/teaching-and-learning/high-potential-and-gifted-education/supporting-educators/assess-and-identify#Assessment1) will help teachers decide which students may benefit from extension and additional challenge. [Effective strategies and contributors to achievement](https://education.nsw.gov.au/teaching-and-learning/high-potential-and-gifted-education/supporting-educators/evaluate) for high potential and gifted learners help teachers to identify and target areas for growth and improvement. In addition, the [Differentiation Adjustment Tool](https://education.nsw.gov.au/teaching-and-learning/high-potential-and-gifted-education/supporting-educators/implement/differentiation-adjustment-strategies) can be used to support the specific learning needs of high potential and gifted students. The [High Potential and Gifted Education Professional Learning and Resource Hub](https://schoolsnsw.sharepoint.com/sites/HPGEHub/SitePages/Home.aspx) supports school leaders and teachers to effectively implement the High Potential and Gifted Education Policy in their unique contexts.

All students need to be challenged and engaged to develop their potential fully. A culture of high expectations needs to be supported by strategies that both challenge and support student learning needs, such as through appropriate curriculum differentiation. (CESE 2020a:6).

### About this resource

All curriculum resources are prepared through a rigorous process. Resources are periodically reviewed as part of our ongoing evaluation plan to ensure currency, relevance and effectiveness. For additional support or advice contact the Teaching and Learning Curriculum team by emailing [secondaryteachingandlearning@det.nsw.edu.au](mailto:secondaryteachingandlearning@det.nsw.edu.au).

**Alignment to system priorities and/or needs**:

This resource aligns to the School Excellence Framework elements of curriculum (curriculum provision) and effective classroom practice (lesson planning, explicit teaching).

This resource supports teachers to address [Australian Professional Teaching Standards](https://educationstandards.nsw.edu.au/wps/portal/nesa/teacher-accreditation/meeting-requirements/the-standards/proficient-teacher) 2.1.2, 2.3.2, 3.2.2, 7.2.2

This resource has been designed to support schools with successful implementation of new curriculum, specifically the NSW Department of Education approved elective course, iSTEM © NSW Department of Education for and on behalf of the Crown in right of the State of New South Wales, 2021.

The resource is produced to assist schools with promoting and implementing the course for the first time. As the course may be taught by teachers from a range of key learning areas, the resource is designed to support teachers from a variety of KLA expertise.

**Department approved elective course**: iSTEM

**Course outcomes**: ST5-1, ST5-2, ST5-3, ST5-4, ST5-5, ST5-6, ST5-7, ST5-8, ST5-9, ST5-10

**Author**: Curriculum Secondary Learners

**Publisher**: State of NSW, Department of Education

**Resource**: Teaching resource

**Related resources**: Further resources to support iSTEM can be found on the Department approved elective courses webpage including course document, sample scope and sequences, assessment materials and other learning sequences.

**Professional Learning**: Join the [Teaching and Learning 7-12 statewide staffroom](https://education.nsw.gov.au/teaching-and-learning/curriculum/statewide-staffrooms) for information regarding professional learning opportunities.

**Universal Design for Learning Tool**: [Universal Design for Learning planning tool](https://education.nsw.gov.au/teaching-and-learning/learning-from-home/teaching-at-home/teaching-and-learning-resources/universal-design-for-learning). Support the diverse learning needs of students using inclusive teaching and learning strategies.

**Consulted with**: Aboriginal Outcomes and Partnerships, Inclusion and Wellbeing, EAL/D.

**Reviewed by**: This resource was reviewed by Curriculum Secondary Learners and by subject matter experts to ensure accuracy of content.

**Creation date**: 21st October 2022

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**Evidence Base**:

‘The long-term vision is for a curriculum that supports teachers to nurture wonder, ignite passion and provide every young person with knowledge, skills and attributes that will help prepare them for a lifetime of learning, meaningful adult employment and effective future citizenship’ (NESA 2020:xi).

The development of the course and the course document as part of department approved electives aims to respond to the goals articulated in NESA’s curriculum review. Consistent messages from the review include:

* ‘flexibility’ was the word most used by teachers to describe the systemic change they want
* teachers need more time to teach important knowledge and skills
* students want authentic learning with real-world application.

This teaching resource provides teachers with some examples of explicit and authentic learning experiences. The option to adjust these learning sequences leads to ‘increased local decision making in relation to the curriculum’ as this ‘is associated with higher levels of student performance’ (NESA 2020:52).

The suggested strategies for teaching and learning align with the principles of explicit teaching. ‘The evidence shows that students who experience explicit teaching practices perform better than students who do not. Explicit teaching reduces the cognitive burden of learning new and complex concepts and skills, and helps students develop deep understanding’ (CESE 2020a:11).

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### Further reading

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