# iSTEM – PBL extension combined with mechatronics and robotics



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## PBL extension combined with mechatronics and robotics

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

Mechatronics and robotics is an emerging industry driving high demand for professionals with skills in systems and computational thinking, mathematics, critical thinking, and complex problem solving. Advancements in this industry 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 a design challenge with content from mechatronics and robotics as well as PBL extension. Students will create machines that are programmable and can carry out a complex series of actions automatically.

### Duration of learning

Indicative time – 50 hours.

### Inquiry question

Can robots access a standard building design?

### 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.

Outcomes referred to in this document are from the [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 with, 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 of 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) later in this document.

### Weeks 1 and 2

Table 1 – PBL extension combined with mechatronics and robotics weeks 1 and 2 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 1 – Introduction and issues**  **ST5-5, ST5-10**  Students:   * utilise components of a design process * define problems or needs to gain understanding of requirements * interpret problems or needs to gain understanding of requirements. | **Teacher**  Introduce driving question: Can robots access a standard building design?  Introduce engineering design challenge and relevant context. The design challenge is to design, prototype, and build a telepresence robot.  **Teacher and students**  Explore benefits for people with restricted mobility using telepresence robots, for example, the requirement of providing an inclusive, mobile, remote presence for identified users by connecting them to learning and activities in classrooms.  Analyse existing solutions and identify relevant issues and engineering principles to research.  **Teacher note**  Engineering design challenges support the development of curiosity, creativity and persistence in students. Design challenges are hands-on projects based on real world science and engineering.  **Extension**  Read [meaningful engagement via robotic telepresence [PDF 365KB]](https://scholarworks.umb.edu/cgi/viewcontent.cgi?article=1077&context=ciee) to assess the use of telepresence devices and the potential impact on inclusive education strategies. | Students can describe the design challenge. | Students are given verbal and non-verbal options to describe the design challenge. |
| **Traditional perspectives**  **ST5-5**  Students:   * investigate traditional technologies used by Aboriginal and Torres Strait Islander people to solve problems * review traditional techniques and perspectives used by Aboriginal and Torres Strait Islander people to solve problems. | **Teacher and students**  Investigate [First Nations watercraft culture](https://australian.museum/learn/first-nations/watercraft-culture/) and the construction of [canoes](https://australian.museum/learn/cultures/atsi-collection/sydney/about-canoes/).  Identify the importance of understanding your local environment and conditions.  Explain the importance of using the right materials at the right time.  Apply traditional perspectives to the current telepresence robot design challenge, for example:   * understanding the local environment * using available materials. | Students can identify the importance of understanding their local environment and conditions.  Students can explain the importance of evaluating the use of materials within a given context. | Student options provided for multiple means of expression for explaining the importance of contextual evaluation of material use. |
| **Telepresence robots**  **ST5-2, ST5-3, ST5-4, ST5-5, ST5-7**  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 * utilise components of a design process * critically evaluate the benefits of using information communication technologies to solve problems. | **Teacher**  Compare the terms mechatronics and robotics.  Present [what’s the difference between mechatronics and robotics? (6:31)](https://www.youtube.com/watch?v=UskYKqraUJo) and/or [what is mechatronics engineering? (6:51)](https://www.youtube.com/watch?v=TSLBm170t7A&t=322s).  Explore a range of mechatronics and robotics systems and the historical development of these systems.  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 2 categories for **remote-controlled** robots:   * tethered * wireless.   Outline 6 levels (0-5) of autonomy used to describe **autonomous** vehicles.  Set design challenge to design, prototype and build a telepresence robot.  Review design challenge and create potential success criteria.  Review existing use cases of telepresence robots, for example:   * [Ohmni Telepresence Robot video (0:30)](https://www.youtube.com/watch?v=D1ljQj203v4) * [Telepresence Robot in Action (2:37)](https://www.youtube.com/watch?v=mZ22wi-nyfg) * [Telepresence in the NSWDoE (6:12)](https://www.youtube.com/watch?v=etaSKVBkuQA) * [Teaching and learning with telepresence [PDF1.5MB]](https://e.issuu.com/embed.html?d=telepresencebrochure&u=technology4learning)   Describe functions and characteristics of telepresence robots.  **Teacher and students**  Evaluate social and practical challenges encountered by operators and people physically present with the robots, and the implications for design of telepresence robots. | Students can describe and give examples of mechatronic and robotic systems. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection using the following steps:   * identify tasks undertaken, new knowledge, understanding or skills * evaluate new knowledge, understanding or skills in relation to previous knowledge * analyse key insights and pose questions regarding their future learning. | Students answer reflective questions, for example:   * What did I learn about mechatronics this week? * Did I learn best when receiving information, applying knowledge, or communicating? | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 2 – Components**  **ST5-4, ST5-5, ST5-6**  Students:   * describe a range of widely known mechatronics and robotics systems * identify major components of mechatronics and robotics systems. | **Teacher**  Demonstrate the function of a variety of components, for example:   * motors – DC, servo and stepper * sensors.   **Students**  Identify mechatronics components and briefly describe their structure and function.  **Teacher and students**  Evaluate what types of components may be used in the design challenge. | Students can identify mechatronics components and briefly describe their structure and function. | Explicitly demonstrate the correct use and connection of components. |
| **Identify – Capabilities and constraints**  **ST5-2, ST5-3, ST5-4, ST5-5, ST5-7**  Students:   * utilise components of a design process * **identify constraints and outline the scope for which the project will be confined** * describe mechatronics and robotics control systems * describe engineering concepts. | **Teacher**  Describe mechatronics and robotics control systems.  Explain the requirements, and relevance, to consider for the robot to travel required distances and negotiate slopes, or ramps, for example:   * maximum range of the robot * maximum incline * sufficient power and locomotion * sufficient traction * ramp surfaces to provide enough grip (friction) * understanding centre of gravity to prevent it from toppling over.   **Teacher and students**  Analyse all functions and capabilities of previously reviewed robots.  Identify and assess known constraints, which may include:   * power requirements * capacity for additional components * construction materials.   Identify data and information that needs to be collected.  Identify milestones for the project.  Measure dimensions of robot components, including mass. | Students can clearly identify relevant constraints. | Model the identification and assessment of constraints. |
| **Identify – Hazards and safe operation**  **ST5-2, ST5-3, ST5-4, ST5-5, ST5-7**  Students:   * utilise components of a design process. | **Teacher**  Identify implications for design of telepresence robots, for example:   * awareness of robot’s location and state * perception of hazards * robot interactions with other humans.   **Teacher and students**  Describe sources of robot hazards, for example:   * human errors * control errors * unauthorized access * mechanical hazards * environmental hazards * electric power sources.   Identify safety issues using telepresence robots in schools. | Students perform a hazard analysis of a telepresence robot. | Model the hazard analysis process with specific reference to a template or scaffold. |
| **Weekly reflection** | **Students**  Complete weekly reflection using the following steps:   * identify tasks undertaken, new knowledge, understanding or skills * evaluate new knowledge, understanding or skills in relation to previous knowledge. | Students answer reflective questions, for example:   * What did I learn about this week? * Did I learn best when receiving information, applying knowledge, or communicating? | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 3 and 4

Table 2 – PBL extension combined with mechatronics and robotics weeks 3 and 4 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 3 – Portable power**  **ST5-4, ST5-5, ST5-6**  Students:   * construct a mechatronics or robotics system using electrical and mechanical components * outline power sources used in mechatronics and robotics systems, for example * electrical power, batteries, photovoltaic cells, Multi-Mission Radioisotope Thermoelectric Generator (MMRTG). | **Teacher**  Outline power sources used in mechatronics and robotics systems.  Explain the concept of power-to-weight ratio (PWR or specific power) with 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 for best 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 the formulae: capacity equals discharge multiplied by discharging time.  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. |
| **Coding environment**  **ST5-4, ST5-5, ST5-6, ST5-8**  Students:   * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **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 which may include:   * controlling a motor * reading sensor values. | 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. |
| **Coding**  **ST5-4, ST5-5, ST5-6, ST5-8**  Students:   * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks * design, simulate and refine mechatronics and robotics systems * design and test circuits in a virtual environment. | **Teacher**  Introduce online coding environment, for example:   * Tinkercad * Makecode * Wokwi   **Students**  Students use online coding environment to design and test circuits, for example:   * using Tinkercad to test microbit python coding.   **Teacher and students**  Explore programming concepts, including:   * control structures * sequence * selection (branching) * repetition (iteration) * relevant data types * text * numbers * boolean * functions (as necessary). | 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 should be completely transferrable 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** | **Students**  Complete weekly reflection using the following steps:   * identify tasks undertaken, new knowledge, understanding or skills * evaluate new knowledge, understanding or skills in relation to previous knowledge. | Students answer a reflective question, for example ‘What did I learn about this week?’ | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 4 – Movement**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * construct a mechatronics or robotics system using electrical and mechanical components * use a range of mechanical devices that produce motion. | **Teacher**  Outline available motor options for making the robotic vehicle move, for example:   * DC motors * gearmotors * servo motors (servos) * 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 control, for example:   * speed * direction.   **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**  **ST5-4, ST5-5, ST5-6**  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 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** | **Students**  Complete weekly reflection using the following steps:   * identify tasks undertaken, new knowledge, understanding or skills * evaluate new knowledge, understanding or skills in relation to previous knowledge. | Students answer a reflective question, for example ‘What did I learn about this week?’ | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 5 and 6

Table 3 – PBL extension combined with mechatronics and robotics weeks 5 and 6 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 5 – Steering options**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * identify major components of mechatronics and robotics systems. | **Teacher**  Outline common steering architectures for robotic cars, 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 and discuss 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. | Explicitly demonstrate the correct use and connection of components. |
| **Brainstorming chassis**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * brainstorm and generate ideas * 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**  Introduce materials, resources and production equipment.  Set the parameters of the task, including available materials, size constraints and allowed time.  **Students**  Measure dimensions of hardware components, including mass.  Identify and assess known relevant constraints, which may include:   * construction materials * layout of components * mounting points * 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 practice, for example:   * record all ideas * thinking activities like trigger cards * consider diverse perspectives.   **Teacher and students**  Brainstorm, collect and organise design ideas. Evaluate options and select the most appropriate chassis design for production. | Students actively participate in classroom discussion.  Students will have accurately collected measurements of components and produced a list of required dimensions. Students will then have used this information to inform their decision making and recorded any brainstorming and design thinking processes. This might 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.   Provide chassis designs and allow students to select the most appropriate from several alternatives. |
| **Designing chassis**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * develop and critically evaluate creative, innovative and enterprising design ideas and solutions to a range of problems * communicate design ideas using a wide range of drawing techniques, including CAD. | **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 and modify as necessary. | Students will have produced technical drawings of their chassis designs. Multiple versions of designs with notes about modifications would indicate 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** | **Students**  Complete weekly reflection by evaluating new knowledge, understanding or skills in relation to previous knowledge. | Students answer reflective questions, for example:   * What did I learn about this week? | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 6 – Build chassis**  **ST5-1, ST5-4, ST5-5, ST5-6**  Students:   * apply problem-solving strategies in the development of practical solutions to project-based learning tasks * work individually or collaboratively to apply an engineering design process to complete real-world project-based learning tasks. | **Teacher**  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. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection by identifying tasks undertaken, new knowledge, understanding or skills. | Students answer a reflective question, for example ‘What practical skills did I learn this week?’ | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 7 and 8

Table 4 – PBL extension combined with mechatronics and robotics weeks 7 and 8 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 7 – installation of base components**  **ST5-4**  Students:   * construct a mechatronics or robotics system using electrical and mechanical components * use a range of mechanical devices that produce motion, for example motors, actuators, gearboxes, gears, chains, pulleys, belts. | **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 and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection by identifying tasks undertaken, new knowledge, understanding or skills. | Students answer reflective questions, for example:   * What did I learn about this week? * Did I learn best when receiving information, applying knowledge, or communicating? | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 8 – Sensors and output devices**  **ST5-4**  Students:   * describe the operation of sensors * describe the operation of output devices. | **Teacher**  Outline types of sensors.  Outline types of output devices.  **Student**  Explain 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 know how 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 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 an 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 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. |
| **Weekly reflection** | **Students**  Complete weekly reflection by 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? | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 9 and 10

**Teacher note:** In week 10 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 5 – PBL extension combined with mechatronics and robotics weeks 9 and10 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 9 – Install sensor**  **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**  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 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. |
| **Install additional sensors**  **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**  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.   **Students**  Continue with tests to confirm all sensors and control systems are functioning correctly. | Students can conduct trials to confirm all sensors and control systems are functioning correctly. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection using the following steps:   * identify tasks undertaken, new knowledge, understanding or skills * evaluate new knowledge, understanding or skills in relation to previous knowledge. | Students answer reflective questions, for example:   * What did I learn about this week? * Did I learn best when receiving information, applying knowledge, or communicating? | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 10 – 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:   * Infrared (IR) * No infrared camera board (NoIR) * Passive infrared (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.**  **Extension (optional)**  Connect camera module to microcontroller/microcomputer on robotic vehicle (or on a test platform) and setup for still image capture and video capture. | Students can recognise image sensors and describe different varieties and their uses. | (Add adjustments and registration) |
| **Video stream**  **ST5-4, ST5-6**  Students:   * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * describe emerging technologies related to mechatronics and robotics engineering. | **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. | (Insert evidence of learning) | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection by evaluating new knowledge, understanding or skills in relation to previous knowledge. | Students answer reflective questions, for example ‘What did I learn about this week?’ | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 11 and 12

Table 6 – PBL extension combined with mechatronics and robotics weeks 11 and 12 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 11 – 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:   * IR * Bluetooth * Wi-fi * cellular (4G and/or 5G) * radio * Global Positioning System (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**  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 will also know some advantages and disadvantages of various wireless technologies. | Provide scaffold or worksheet to assist student recall and organisation of knowledge. |
| **Learn about 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. | Provide scaffold or instructions to assist with process-based activities. |
| **Install Bluetooth**  **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 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**  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. | Provide visual scaffolds or instructions to assist with process-based installation. |
| **Weekly reflection** | **Students**  Complete weekly reflection by identifying tasks undertaken, new knowledge, understanding or skills | Students answer reflective questions, for example ‘What did I learn about this week?’ | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 12 – Wi-fi Communication**  **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**  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 to a microcontroller via wi-fi.  Students can test code on microcontroller by sending commands via wi-fi. | (Add adjustments and registration) |
| **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 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**  Investigate creating mobile apps which can connect to the wi-fi module to send commands to robotic platform (and receive feedback). | Students can install and test wi-fi components on their device. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection by evaluating new knowledge, understanding or skills in relation to previous knowledge. | Students answer a reflective question, for example ‘What did I learn about this week?’ | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 13 and 14

Table 7 – PBL extension combined with mechatronics and robotics weeks 13 and 14 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 13 – Telepresence device holder**  **ST5-4, ST5-6**  Students:   * apply components of a design process * communicate design ideas using a wide range of drawing techniques, including CAD * develop and critically evaluate creative, innovative and enterprising design ideas and solutions to a range of problems * design solutions, synthesise ideas and plan. | **Teacher**  Revise design solutions, synthesise ideas, and plan using skills from [STEM fundamentals](https://education.nsw.gov.au/teaching-and-learning/curriculum/department-approved-courses/istem#/asset4).  Present different telepresence device holder ideas, for example:   * [phone holders](https://www.printables.com/social/290763-vanderson-de-andrade-santos/collections/238067) * [open-source telepresence robot](https://www.thingiverse.com/thing:3360113/files).   **Teacher and students**  [Brainstorm](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/542#.Y5-A_wikv4w.link) possible solutions, limitations, and resources needing consideration when designing the telepresence device holder.  **Students**  Produce a range of annotated design drawings of their chosen solution, for example, sketches, rendering, detailed drawings.  Use a computer-aided design (CAD) package to produce working drawings or illustrations of the design solutions. | Students brainstorm and communicate innovative solutions to problems related to space using a range of drawing techniques, including CAD. | (Add adjustments and registration) |
| **Telepresence device**  **ST5-4, ST5-6**  Students:   * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects. | **Teacher**  Review design ideas from previous lesson.  **Explain the use of building materials for the telepresence stand, for example:**   * **3D printed components** * **laser cut components** * **recycled components** * **lamp stand** * **clamp** * **elastics**   **Teacher and student**  Design and sketch a telepresence stand. Design or choose components and gather materials.  Cut, print, assemble or build components. | Students communicate graphically innovative solutions to problems related to space using a range of drawing techniques, including CAD. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection by identifying tasks undertaken, evaluating new knowledge, understanding or skills. | Students answer a reflective question, for example ‘What did I learn about this week?’ | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 14 – Prototype build**  **ST5-4, ST5-6**  Students:   * construct detailed models and prototypes * prototype design solutions * 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 * demonstrate innovation and entrepreneurial activity and communicate solutions to problems involving mechatronics or robotics. | **Teacher**  Outline the purpose of prototyping design ideas.  Review identified requirements and success criteria.  Explain the concept of prototype fidelity.  **Teacher and students**  Decide the fidelity required for this design challenge.  **Teacher**  Facilitate the use of tools and equipment by the students while providing active supervision.  **Students**  Continue design and construction of components for the telepresence robot prototype, using a range of different technologies.  Attach telepresence device to robot and test functioning of device.  Test function of entire prototype robot. | Students demonstrate practical skills, safely using appropriate tools, equipment, and techniques, to produce prototypes.  Students demonstrate capacity to communicate and collaborate with peers to solve problems that may arise. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection by evaluating new knowledge, understanding or skills in relation to previous knowledge. | Students answer a reflective question, for example ‘What did I learn about this week?’ | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.  Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 15 and 16

Table 8 – PBL extension combined with mechatronics and robotics weeks 15 and 16 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 15 – Coding planned paths**  **ST5-5**  Students:   * use a range of mechanical devices that produce motion * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **Teacher**  Demonstrate more complex challenges, for example code robot to move:   * forward set distance and return to initial spot * forward x, turn left/right, forward y * around the perimeter of a two-dimensional shape.   **Students**  Write algorithms and code robots to complete more complex challenges.  Test code, evaluate results, and modify as necessary.  **Teacher**  Demonstrate how to measure the time taken to travel a set distance in a straight line using (with code) a set speed setting.  Explain how to calculate the speed (velocity) from the time taken to travel a set distance using:Velocity = distance over time  **Students**  Record the time taken for the robot to move in a straight line, a set distance with different speed settings.  Calculate the maximum speed of the robot in metres per second on a level surface. | Students can successfully code robot to accomplish a series of navigational movements to travel from an initial point to a destination. | Model the use of code to complete more complex challenges. Provide examples that students can modify to create successful movement. |
| **Mapping and routes**  Students:   * use a range of mechanical devices that produce motion * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks * robotic navigation, obstacle avoidance and control. | **Teacher**  Introduce the requirement for mapping a space to assist creation of navigation code.  Model the use of measuring tools for data collection, for example:   * measuring tape * compass * photogrammetry * CAD * assign space or designate test route for mapping of robot path.   **Student**  Use designated tools and equipment to map route or space. | Students can use appropriate equipment to sketch an appropriately scaled 2D map of a given area/route or can use digital technologies to capture a 3D photogrammetry terrain map. | Provide a map template with key features of area or route to scaffold the process for students. |
| **Code for a destination**  **ST5-1, ST5-2, ST5-4, ST5-5**  Students:   * use a range of mechanical devices that produce motion * develop and implement code to control mechatronics and robotics devices in order to accomplish tasks. | **Teacher**  Review programming language features necessary to code the robot for the selected route (multi-leg journey).  **Students**  Design an algorithm for the robot to travel from an origin point to a chosen destination.  Program the robot to travel the selected route. Test for syntax and logic errors.  Modify code as necessary to successfully travel route in one continuous sequence. | Students can design and modify code as necessary to successfully travel route in one continuous sequence. | Provide sample codes and code templates to assist students who may find syntax overly challenging. |
| **Weekly reflection** | **Students**  Complete weekly reflection by identifying and evaluating new knowledge or skills considering previous knowledge. | Students answer a reflective question, for example ‘What did I learn about this week?’ | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 16 – Testing**  **ST5-4, ST5-5, ST5-6**  Students:   * identify and justify the use of appropriate research methods to solve contextualised STEM-based problems * manage data collection to support design projects * analyse data to inform decisions, draw conclusions and critically evaluate engineering design projects * critically evaluate solutions * use mechatronics and robotics equipment to carry out experiments, solve problems and construct projects * apply components of a design process * use fundamental techniques in arithmetic, measurement, and geometry to complete tasks. | **Teacher**  Introduce firsthand investigation, for example:   * What is the maximum incline the telepresence robot can climb? * What is the maximum height of a bump the telepresence robot can go over? * Explain the importance in undertaking tests to gather empirical data to provide evidence for making decisions.   **Teacher and students**  Design the firsthand investigation and assign variables, for example:   * **Set a standard incline angle (controlled variable) and cha**nge the position of a weight **on the robot (independent variable) to measure the time to travel a distance (dependent variable)** * **Set a standard weight on the robot (controlled variable) and change the incline angle (independent variable) to measure the time taken to travel a certain distance (dependent variable)** * **Set a standard weight and incline (controlled variables) and change the surface on the incline** or wheels (**independent variable) and measure the time taken to travel a certain distance (dependent variable).**   Write the aim, hypothesis, and method for the firsthand investigation.  Procure materials for the investigation to prepare for next lesson. | Students can design a viable firsthand investigation with accurate independent, dependent, and controlled variables. | (Add adjustments and registration) |
| **Investigation**  **ST5-4, ST5-5, ST5-6**  Students:   * manage data collection to support design projects * analyse data to inform decisions, draw conclusions and critically evaluate engineering design projects. | **Teacher**  Review investigation method and risk assessment. Mitigate any safety concerns.  **Students**  Conduct firsthand investigation  **Teacher and students**  Analyse data from investigation and communicate results in a format appropriate for the intended audience, for example:   * [scientific report [DOC 561KB]](https://education.nsw.gov.au/content/dam/main-education/teaching-and-learning/curriculum/elective-courses/media/documents/istem-s5-writing-scientific-reports-teacher-guide.docx) * [engineering report [DOC 1.57MB]](https://education.nsw.gov.au/content/dam/main-education/teaching-and-learning/curriculum/elective-courses/media/documents/istem-s5-writing-engineering-reports-teachers-guide.docx) * infographic. | Students demonstrate practical skills, safely using appropriate tools, equipment, and scientific method to undertake firsthand investigation.  Students demonstrate capacity to accurately assess data to draw conclusions or produce further questions. | Provide scientific report template to scaffold student progress through investigation.  Joint construct the aim, hypothesis, method, analysis and conclusion to model thinking throughout the investigation. |
| **Weekly reflection** | **Students**  Complete weekly reflection by identifying and evaluating new knowledge or skills considering previous knowledge. | Students answer a reflective question, for example ‘What did I learn about this week?’ | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 17 and 18

Table 9 – PBL extension combined with mechatronics and robotics week 17 and 18 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 17 – Iteration**  **ST5-1**  Students:   * critically evaluate solutions * iterate designs * apply problem-solving strategies in the development of practical solutions to project-based learning tasks * work individually or collaboratively to apply an engineering design process to complete real-world project-based learning tasks. | **Teacher**  Provide guidance to groups on managing tasks.  Facilitate the use of tools and equipment by the students while providing active supervision.  **Students**  Review and discuss findings within groups and decide what further modifications may need to be made.  Present an update of design/changes to the teacher.  Perform necessary modifications to designed parts, assemble hardware components and build final design.  **Teacher**  **Assist students in fabrication of design using available resources.**  **Ask prompting questions to assist adaptive process, for example:**   * **What happens to the stability (centre of gravity) if we put a** weight in different places on the robot? * **What happens to stability if we make the wheelbase wider or longer?**   **Teacher and students**  **Test design solution against design challenge criteria.** | Students demonstrate practical skills, safely using appropriate tools, equipment, and techniques, to produce final design.  Students demonstrate capacity to evaluate and modify designs. | (Add adjustments and registration) |
| **Evaluate final design**  **ST5-1**  Students:   * effectively communicate solutions to problems using relevant information communication technologies. | **Teacher**  Outline Product Qualification as a process to determine whether a product design is fit for purpose (specified operating and environmental conditions).  **Teacher and students**  Review the requirement of providing an inclusive, mobile, remote presence for identified users by connecting them to learning and activities in classrooms.  **Students**  Test the continued operation of the robot under normal (or expected) operating conditions.  Collect and organise data to compare with test data from earlier prototype designs.  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 physical accessibility. | Students can evaluate the operation and performance of the robot, using the success criteria, under normal (or expected) operating conditions. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection by identifying and evaluating new knowledge or skills considering previous knowledge. | Students answer a reflective question, for example ‘What did I learn about this week?’ | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 18 – Engineering report**  **ST5-4, ST5-5, ST5-6**  Students:   * effectively communicate solutions to problems using relevant information communication technologies * document design processes using engineering reports or design portfolios. * communicate and share solutions * justify the selection of information communication technologies, tools, materials and processes to produce a solution to an identified problem. | **Teacher preparation**  Use the [iSTEM writing engineering reports teacher guide [DOC 1.57MB]](https://education.nsw.gov.au/content/dam/main-education/teaching-and-learning/curriculum/elective-courses/media/documents/istem-s5-writing-engineering-reports-teachers-guide.docx) as a scaffold for creating an engineering report template.  **Teacher**  Review engineering reports for students and review previous engineering reports completed in iSTEM or introduce students to engineering report template.  Model the creation of an engineering report for students.  **Teacher and students**  Brainstorm ideas and develop joint sections of the engineering report together, for example the executive summary.  **Students**  Complete engineering report for their design challenge solution.  **Teacher**  Support students in developing their engineering report, especially evaluations and recommendations. | Students produce an engineering report with final evaluation, including data analysis, comparison between design drawings and final prototype, and suggested improvements. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflection by identifying and evaluating new knowledge or skills considering previous knowledge. | Students answer a reflective question, for example ‘What did I learn about this week?’ | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 19 and 20

Table 10 – PBL extension combined with mechatronics and robotics weeks 19 and 20 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 19 – Communicate**  **ST5-8**  Students:   * effectively communicate solutions to problems using relevant information communication technologies * apply high level communication skills to pitch solutions to a range of different audiences * communicate and share solutions. | **Teacher**  Briefly describe the role of a pitch, for example:   * to generate finance for further development or production * creating product awareness * testing ideas on potential customers.   Present examples of entrepreneurs and engineers pitching or demonstrating their design ideas, for example:   * [portable water purifier (9:14)](https://www.ted.com/talks/michael_pritchard_how_to_make_filthy_water_drinkable?language=en) * [shark tank baby spoon (7:07)](https://www.youtube.com/watch?v=BaUkuszb7dg).   Model the creation and features of a pitch, for example:   * information about the problem the product solves * overview of the product * unique features of the product * persuasive language.   **Students**  Create a 1-2 minute pitch video that demonstrates the benefits of their design in solving the design challenge.  **Extension**  Seek feedback from businesses or tertiary institutions on design ideas and pitches. | Students can articulate the role of a pitch to communicate a design solution.  Students produce a pitch that communicates their design solution properties and effectiveness. | Use closed captions when viewing video to assist understanding and vocabulary building. Pause or replay video to evaluate different features of pitches.  Adjust the required pitch based on student needs, for example inclusion may be enhanced for students with severe anxiety by requesting a pitch from all students with pictures of the design, text, and music. |
| **Communicate**  **ST5-8**  Students:   * apply high level communication skills to pitch solutions to a range of different audiences * communicate and share solutions. | **Teacher and students**  Review progress of the design pitch.  **Students**  Continue to create their design pitch video. | Students plan a pitch that communicates their design solution and demonstrates features of a pitch, for example:   * information about the problem the product solves * overview of the product * unique features of the product * persuasive language.   Students demonstrate critical thinking, creativity, problem-solving, entrepreneurship, and engineering design skills in presenting their prototypes and designs. | Actively assess student progress with their pitch and assist where appropriate. |
| **Feedback**  **ST5-8**  Students:   * effectively communicate solutions to problems using relevant information communication technologies * apply high level communication skills to pitch solutions to a range of different audiences. | **Teacher**  Organise a shared digital space for students to post their pitch videos.  **Students**  Watch peer’s pitch videos and provide constructive feedback written notes for other students.  Submit feedback to teacher.  **Teacher**  Preview submitted peer feedback to screen for negativity. Provide appropriate feedback to students. | Students demonstrate capacity to provide positive and constructive feedback to their peers.  Assess features of a pitch, for example:   * information about the problem the product solves * overview of the product * unique features of the product * persuasive language. | Model the feedback process for students and provide a scaffold for feedback responses.  Create a socially supportive classroom environment with a culture of positive feedback, encouragement and mutual support. |
| **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? * What did I enjoy doing this week? | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 20 – Innovation**  **ST5-2**  Students:   * investigate organisations who produce innovative solutions and evaluate their processes * describe emerging technologies related to mechatronics and robotics engineering. | **Teacher**  Present [the best robotics start-ups (12:10)](https://www.youtube.com/watch?v=GWVzS4TYV7s).  **Students**  Select 2 of the companies presented and identify the problem they were solving and the solution they are developing.  **Teacher and students**  Investigate organisations who produce innovative solutions and evaluate their processes, for example:   * [How Apple is Organised for Innovation (4:35)](https://www.youtube.com/watch?v=5hENFA3CJUY) * [Why is SpaceX so innovative? (6:20)](https://www.youtube.com/watch?v=pvIixu4iies) * [How do you bring innovation to work? (3:47)](https://www.youtube.com/watch?v=sF6_deFmjmY) * [Creative Thinking (5:10)](https://www.youtube.com/watch?v=cYhgIlTy4yY).   Identify effective innovation processes, for example:   * diverse people, ideas, and background knowledge * building trust and being honest allowing a culture of risk taking * respecting diverse thinking and ways of knowing * iterative development and rapid prototyping. | Students can describe some emerging technologies related to robotics.  Students can describe effective innovation mindsets and processes. | Use closed captions when viewing video to assist understanding and vocabulary building. Pause or replay video to identify different entrepreneurial mindsets and skills. |
| **Future of robotics**  **ST5-2**  Students:   * describe emerging technologies related to mechatronics and robotics engineering * explain the effects of mechatronics and robotics innovation on current and future careers * outline machine learning (ML) and artificial intelligence (AI) uses in mechatronics and robotics systems. | **Teacher**  Present [watch this AI robot pick peppers with a tiny saw (2:07)](https://www.youtube.com/watch?v=5chk9Sory88) and [Traptic farming robots (1:48)](https://www.youtube.com/watch?v=ZPmsvnouJ9w).  **Teacher and students**  Outline 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. | (Add adjustments and registration) |
| **Careers**  **ST5-4, ST5-5, ST5-6**  Students:   * 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 career profile video for [Ivana Popovac (2:18)](https://www.youtube.com/watch?v=nBiJ-2eOiQQ).  **Teacher and students**  Explore the career profile for Ivana Popovac. **Outline the pathway** Ivana took **to work in** systems engineering.  **Teacher**  Present students with [STELR women in STEM](https://stelr.org.au/womeninstem/) website.  **Students**  Explore the STELR women in STEM website. Examine two career profiles of personal interest. Investigate the nature of work undertaken and the pathways into professions which utilise STEM skills.  Create and share a brief summary of one career profile. | Students can identify STEM careers.  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. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflections by identifying tasks undertaken, new knowledge, understanding, or skills. | Students answer a reflective question, for example ‘What did I learn about innovation and STEM careers this week?’ | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |

## Additional information

**Resource evaluation and support**: Please complete the following [feedback form](https://educationstandards.nsw.edu.au/wps/portal/nesa/teacher-accreditation/meeting-requirements/the-standards/proficient-teacher?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/557), [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/564).

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 © 2021 NSW Department of Education for and on behalf of the Crown in right of the State of New South Wales.

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**: ST-1, ST-2, ST-3, ST-4, ST-5, ST-6, ST-7, ST-8, ST-9, ST-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, Macquarie Fields High School, and Sydney University.

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

**Creation date**: 21 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).

## References

**Links to third-party material and websites**

Please note that the provided (reading/viewing material/list/links/texts) are a suggestion only and implies no endorsement, by the New South Wales Department of Education, of any author, publisher or book title. School principals and teachers are best placed to assess the suitability of resources that would complement the curriculum and reflect the needs and interests of their students.

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