# iSTEM – Project-based learning: Localised food production



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## Project-based learning: Localised food production

Project-based learning is an approach to teaching and learning that engages students in rich and authentic learning experiences. It is a transformative teaching practice that requires a commitment to innovation and contemporary pedagogies. In project-based learning environments, students gain knowledge and skills by investigating and responding to engaging questions, problems or challenges.

In this core topic, students develop and realise solutions to STEM focused project-based learning tasks. It requires students to utilise problem-solving strategies to apply appropriate design, production and evaluation skills to real-world problems. Teachers are encouraged to use project-based learning pedagogies to extend student-centred learning opportunities across a range of specialised topics. Teachers may choose to select problems which are relevant to local school contexts.

To complete this topic students should follow design thinking processes. Curriculum Secondary Learners have produced a sample [iSTEM engineering design process and engineering report guide](https://education.nsw.gov.au/teaching-and-learning/curriculum/department-approved-courses/istem#/asset4) to provide a scaffold that will engage students in their personal learning journey.

### Duration of learning

Indicative time – 25 hours.

### Inquiry question

Where can we grow food?

### 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.

### 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. Core modules must precede options in the delivery of the course. Consult the course document for further details on timing of core and options.

## 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 to record adjustments and enhancements that are made to the learning sequence during its implementation. For further advice see [inclusive practice resources for secondary school](https://education.nsw.gov.au/campaigns/inclusive-practice-hub/secondary-school).

Aboriginal perspectives which relate to the individual school community should be included in learning sequences. Consultation with local Aboriginal groups including local NSW Aboriginal Education Consultative Group (AECG) is recommended. For further advice see [Aboriginal education in NSW public schools](https://education.nsw.gov.au/teaching-and-learning/aec/aboriginal-education-in-nsw-public-schools).

EAL/D learners enrolled in iSTEM who are at the consolidating phase of acquiring English language skills will benefit from explicit teaching of subject-specific terminology and may require a little more time to absorb the information. Consider language and cultural demands of content and tasks and beware of barriers to learning due to assumed knowledge. Scaffolded activities which build the field to introduce new concepts and language, message abundancy, modelling and deconstruction of key language features and structures will assist EAL/D learners. For further advice see [English as an additional language or dialect](https://education.nsw.gov.au/teaching-and-learning/curriculum/multicultural-education/english-as-an-additional-language-or-dialect/planning-eald-support/english-language-proficiency).

HPGE learners may benefit from extension and additional challenge in iSTEM. It is important to assess and identify these learners to target areas of growth and improvement. For further advice see [Teaching and learning HPGE](https://education.nsw.gov.au/teaching-and-learning/high-potential-and-gifted-education).

### Weeks 1 and 2

Table – Project-based learning weeks 1 and 2 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 1 – Traditional Aboriginal techniques****ST5-5**Students:* examine traditional technologies used by Aboriginal and Torres Strait Islander peoples to solve problems
* examine traditional techniques and perspectives used by Aboriginal and Torres Strait Islander peoples to solve problems.
 | **Teacher**Introduce traditional techniques and perspectives used by Aboriginal and Torres Strait Islander peoples to manage the environment and harvest food.Present [Indigenous fire methods protect land before and after the Tathra fire (11:00)](https://youtu.be/RM72NtXxyLs).Describe the process of cultural burning (in consultation with local AECG or community leaders).**Teacher and students**Discuss some problems, past and present, that cultural burning solves. | Students can identify traditional techniques to manage the environment.Students can describe cultural burning. | Use closed captions when viewing video to assist understanding and vocabulary building. Pause video to assess student understanding at appropriate points.Provide key terms to assist with vocabulary building and knowledge acquisition. |
| **Traditional Aboriginal food and medicine****ST5-5**Students:* examine traditional techniques and perspectives used by Aboriginal and Torres Strait Islander peoples to solve problems.
 | **Teacher**Introduce traditional techniques and perspectives used by Aboriginal and Torres Strait Islander peoples to locate and harvest food and use local remedies for treating illnesses.**Students**Explore [Food and Agriculture](https://www.deadlystory.com/page/culture/Life_Lore/Food) to identify potential health or societal benefits of certain foods and medicines.**Teacher**Introduce current problems with agriculture, for example:* water restrictions
* overuse of fertilisers, pesticides, and herbicides
* carbon emissions from food transport.

**Teacher and students**Identify how Aboriginal perspectives could be used to address present-day problems, for example:* alternative sources of protein which may generate lower carbon emissions
* diversified honey production from honey ants
* kangaroo meat as a low cholesterol, low water use meat alternative
* antibiotics from emu bush may help with antibiotic resistant bacteria
* decrease carbon emissions by sourcing food locally.

Briefly introduce future practices that could increase yields whilst decreasing:* carbon emissions
* water use
* fertiliser, pesticide, and herbicide use.
 | Students can identify traditional food and medicinal treatments.Students can describe current agricultural issues.Students can identify how Aboriginal perspectives and techniques could help solve current agricultural problems. | Skim and scan webpage to help orientate students. Demonstrate active reading, such as pre-read, read and rereading for processing, of information to extract relevant information. |
| **Food security and local food production****ST5-3**Students:* utilise components of a design process
* define problems or needs to gain understanding of requirements.
 | **Teacher**Present [Growing Tomatoes Indoors with 94% Less Water and No Soil (6:01)](https://www.youtube.com/watch?v=5Fq6PQl7fr8) as an example of accelerated growth farming systems.Identify modern food production principles that maximise yield whilst minimising resource use to produce a profitable and ethical business.Describe current and emerging food production issues, for example:* fertiliser cost and runoff
* fuel cost, carbon emissions and the carbon economy
* food security and transportation issues
* water use minimisation especially in arid environments
* ageing demographics and reliance on automation
* decrease in arable land per capita.

**Teacher and students**Explore secondary sources that identify emerging food production issues and describe potential solutions, for example:* [Vertical Farm Technology (13:52)](https://www.youtube.com/watch?v=jKcliuGdJdU)
* [Infinite Acres – enclosed vertical farms](https://www.infinite-acres.com/)
* [underground farms (3:31)](https://www.youtube.com/watch?v=QQ8wcBmB_rQ)
* [smart gardens](https://www.trendhunter.com/trends/smart-gardens)
* [ten benefits of hydroponic farming](https://puregreensaz.com/benefits-urban-farming/)
* [hydroponics at home using plastic bottles at your window wall (3:38)](https://www.youtube.com/watch?v=Yx5fLrmj8v4).

Share and collate ideas on digital platform or butcher paper.Explore different ideas that have been shared in regards to the question ‘How do we solve emerging agriculture problems through localised food production?’**Teacher**Explicitly link localised food production to design challenge.Introduce overarching design challenge ‘Create an indoor plant growing system’.**Teacher note:**There is a wide variety of local food production systems. Specify the challenge to suit your context and resources. | Students can describe emerging food production problems and potential solutions.Students can describe the inquiry question and can explain reasons why it is important. | Select secondary resources that are most relevant to school context and suitable for your students. |
| **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 the light of previous knowledge
* analyse key insights and pose questions regarding their future learning.
 | Students answer reflective questions, for example:* What did I learn about food security this week?
* Did I learn best when receiving information, applying knowledge, or communicating?
 | Modelling or providing a template 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 – Building the context****ST5-3**Students:* utilise components of a design process
* define problems or needs to gain understanding of requirements
* identify constraints and outline the scope for which the project will be confined.
 | **Teacher**Review food production ideas and examples from last lesson.Present [Vertical farms could take over the world (11:03)](https://www.youtube.com/watch?v=J4SaSfnHK3I).**Extension**Identify the potential biases in this video.**Students**Identify factors that need to be accounted for when indoor farming.**Teacher and students**Evaluate aspects of vertical farming, for example:* pesticide use
* recycled water
* transport costs
* debatable flavour
* controlling the environment
* costs.

**Students**Research details of indoor farming designs and ideas, for example:* Do plants need soil?
* What types of watering or lighting systems can be used?
* What nutrients do plants need?
* Do designs change as plants grow?
* Collate and communicate questions and answers.
 | Students can recall food production problems and potential solutions.Students can identify sources of information and describe features of vertical and indoor farms.Students can identify potential bias in presented information. | Use closed captions when viewing video to assist understanding and vocabulary building. Pause video to assess student understanding and discuss pertinent points. |
| **Divergent thinking****ST5-2**Students:* brainstorm and generate ideas, for example
* divergent thinking.
 | **Teacher**Introduce and define divergent thinking.**Teacher and students**Complete several [finish the shape drawing activity](https://makeamarkstudios.com/fostering-divergent-thinking-skills-in-your-art-class/#:~:text=%232%2D%20Finish%20the%20shape%20drawing%20activity).Share sketches and discuss the benefits of divergent thinking activities.**Teacher**Explain the importance of thinking about what is possible before thinking about limitations.**Teacher and students**Complete the [collaborative drawing game](https://makeamarkstudios.com/fostering-divergent-thinking-skills-in-your-art-class/#:~:text=%234%2D%20Collaborative%20drawing%20game.%20Draw.%20Pass.%20Collaborate.%20Repeat), with an emphasis on sketching a possible design for an indoor plant growing system.Compare the different types of sketches. | Students can define divergent thinking.Students engage in divergent thinking activities to produce sketches. | (Add adjustments and registration) |
| **Convergent thinking****ST5-2, ST5-3**Students:* design solutions, synthesise ideas and plan, for example
* convergent thinking.
 | **Teacher**Present [Convergent Thinking Versus Divergent Thinking (1:51)](https://www.youtube.com/watch?v=cmBf1fBRXms). Seek initial reactions from students to gauge understanding.Present [Convergent vs Divergent Thinking (3:38)](https://www.youtube.com/watch?v=xjE2RV6IQzo).**Teacher and students**Briefly compare both videos to see how they presented similar definitions in different ways.Identify the importance of diverse ways of presenting information.**Teacher**Explain that divergent thinking is effective for idea generation and convergent thinking effectively converts ideas into an actionable design or prototype.Review learning with respect to the overall design challenge.Outline the resources that will be available for the design challenge. | Students demonstrate understanding of divergent and convergent thinking.In their portfolio, students can identify resources they may need and possible constraints.Students can identify the scope and nature of the challenge. | Review key concepts and vocabulary before viewing video. Use closed captions and provide the transcript.Pause and explain concepts in the video to assist with understanding. |
| **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 this week?
* When did I learn best?
 | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task. |

### Week 3

**Note:** This week uses 3D printing. Teachers are encouraged to adjust the sequence to suit the school context and resources. The level of computer-aided design (CAD) use should be adjusted to suit your students’ level of proficiency.

Table – Project-based learning week 3 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 3 – CAD****ST5-4, ST5-6**Students:* demonstrate proficiency in the use of CAD and computer-aided manufacturing (CAM) systems
* select and apply appropriate research methods to solve contextualised STEM-based problems.
 | **Teacher**Review the use of CAD from STEM fundamentals.Present [Meaningful uses of 3D Printing in Gardening (9:55)](https://www.youtube.com/watch?v=71-nQTSJ17Q&t=43s). Evaluate designs that are presented and propose changes.Review process of downloading appropriate 3D printing files and importing it into a relevant CAD program.**Students**Search reputable websites for planter pot 3D printing files, for example:* [instructables self-watering planter](https://www.instructables.com/3D-Printed-Self-Watering-Planter/)
* [printables seed starter](https://www.printables.com/model/61902-small-self-watering-seed-starter)
* [all3dp cascaqua](https://all3dp.com/cascaqua-aquaponic-fish-plants/)
* [Thingiverse modular hydroponic tower garden](https://www.thingiverse.com/thing%3A3405964).

Download appropriate files and open in a familiar CAD program.Use this program to adjust the chosen design, for example:* change size
* change shape
* add designs.

**Teacher**Use questioning to check designs and understanding. | Students can locate and manipulate appropriate files for CAD and CAM. | Use closed captions when viewing video to assist understanding and vocabulary building. Pause video to assess student understanding at key design points.Assist students with search by providing a list or prompt of desirable web pages that will assist design process.Use [graduated](https://education.nsw.gov.au/content/dam/main-education/campaigns/inclusive-education-hub/pdf/resources/Graduated_Guidance_Poster_FINAL_NSW_A4_-_TAGGED.pdf) guidance to scaffold student independence when developing or practising CAD skills. |
| **CAM****ST5-6**Students:* construct models and prototypes using a variety of media
* demonstrate proficiency in the use of CAD and CAM systems.
 | **Teacher**Revise activity from last lesson.Outline potential issues with 3D printing vessels, for example:* biodegradability of filament
* slicing settings
* toxicity.

**Teacher and students**Explore [how to make waterproof 3D prints](https://all3dp.com/2/waterproof-3d-print-pla/) to find solutions to potential problems.**Student**Complete design alterations from last lesson in CAD and commence 3D printing. | Students can locate and manipulate appropriate files for CAD and CAM.Students can prepare files for 3D printing. | Model strategies that assist understanding if reading complicated texts (professional articles), for example:* explicit breakdown of titles, headings, and keywords
* highlight key sentences pertaining to the design challenge.
 |
| **Evaluate sample design****ST5-9**Students:* explain how CAD and CAM systems are used in the engineering design process
* investigate information communication technologies, tools, materials, and processes to produce a solution to an identified problem
* evaluate the benefits of using information communication technologies to solve problems
* collect and organise data in a range of formats
* analyse data to inform decisions and draw conclusions, using a range of evaluation techniques.
 | **Teacher**Suggest criteria for students to evaluate their chosen designs and alterations, for example:* Is it waterproof?
* How strong is it?
* Is the filament toxic or biodegradable?

**Student**Evaluate construction of the 3D printed model and its application to the use of 3D printing for the design challenge, for example:* Is it cost effective?
* Is it preferable to other materials?

Sketch additional designs with annotations and notes.**Teacher and students**Evaluate the use of CAD and CAM systems in the engineering design process. | Students can evaluate the use of CAD, CAM and 3D printing for their design challenge. | Model an evaluation of a design and remind students of the evaluation process from STEM fundamentals and provide evaluation prompts, for example:* What revisions or improvements can be made to the design?
* What was discovered from the testing and experimentation of the solution?
* Is there more experimentation and testing required?
 |
| **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 CAD this week?
* Why did I enjoy doing this?
 | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |

### Week 4

**Note:** This week is designed to create baseline understanding of specific technologies schools may use in their eventual designs. Teachers are encouraged to adjust Week 4 to suit their school context, student ideas and school resources. To maximise design opportunities, a range of sensors, microcontrollers, meters, lighting, irrigation systems, or timers could be explored this week.

Table – Project-based learning week 4 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 4 – Sensors****ST5-6, ST5-9**Students:* investigate information communication technologies, tools, materials, and processes to produce a solution to an identified problem.
 | **Teacher**Explain to students the use of sensors or meters to take readings for efficient growth of plants.Introduce specific microcontrollers and sensors or meters that could be used by the class.Demonstrate sensor or meter setup (and/or provide video links) for the system you will be using, for example:* [ambient light sensor (5:55)](https://www.youtube.com/watch?v=hUUlJuWxy00)
* [FarmBeats sensor suites](https://docs.microsoft.com/en-us/training/educator-center/instructor-materials/farmbeats-for-students)
* [soil moisture sensor (1:11)](https://youtu.be/1h6D_pkeoks)
* [pH and electrical conductivity meters (22:07)](https://www.youtube.com/watch?v=SvksjH9gedQ).

**Teacher and students**Setup microcontroller and sensor including programming for specific use of sensor. | Students demonstrate capacity to effectively use designated sensors or meters to collect potentially actionable data. | Model the use of controllers and sensors. Create a step-by-step guide for sensor setup and joint read this guide to help ensure understanding. |
| **Programming****ST5-6, ST5-9**Students:* investigate information communication technologies, tools, materials, and processes to produce a solution to an identified problem.
 | **Teacher**Introduce specific microcontroller, software or effectors that will be used and demonstrate the programming or use of controller and effector, for example:* [LED glowbit matrix (15:33)](https://youtu.be/VPNqCwmIarY)
* timers
* water pump
* grow lights.

**Teacher and students**Apply programming knowledge to create action from programming, for example:* LED colours
* grow light timing
* water flow or pump for certain duration.
 | Students demonstrate capacity to effectively program and use designated controllers to change conditions. | Model the use of effectors. Create a step-by-step guide for setup and joint read this guide to help improve understanding. |
| **Design integration****ST5-2, ST5-6, ST5-9**Students:* investigate information communication technologies, tools, materials, and processes to produce a solution to an identified problem.
 | **Teacher and students**Review effector, component, and sensor programming.Evaluate how the use of controllers, sensors and effector components could be used in any potential future designs in respect to the design challenge.**Extension**Use microcontrollers to interpret sensor readings and action programmed responses, for example:* a decrease in Lux turns on lights
* a decrease in soil moisture activates pump
* an increase in temperature or humidity switches on a fan.
 | Students can assess the use of controllers, sensors, and effectors within the context of the design challenge.Students can communicate their evaluations and ideas in their portfolio.**Extension**Students can apply knowledge to alter programming and alter effector response, for example, changing:* LED light colour or timing
* water pump/valve timing
* temperature ranges.

Students use convergent thinking to refine possible design ideas for design challenge. | Model the evaluation of components and how they could possibly be integrated in future designs. |
| **Weekly reflection** | **Students**Complete weekly reflection by identifying and evaluating new knowledge or skills. | Students answer reflective questions, for example:* What did I learn about components this week?
* When did I learn best?
 | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task. |

### Weeks 5 and 6

Table – Project-based learning weeks 5 and 6 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 5 – Research design****ST5-2, ST5-7, ST5-10**Students:* brainstorm and generate ideas, for example
* technologies and techniques
* identify and use a broad range of problem-solving strategies in the development of practical solutions to project-based learning tasks
* investigate organisations who produce innovative solutions and evaluate their processes, for example
* start-ups, incubators, small and medium-sized enterprises.
 | **Teacher**Review information regarding the overarching design challenge ‘Create an indoor plant growing system’ and local food production.**Teacher and students**Access [vertical farm design and innovation (1:31)](https://www.youtube.com/watch?v=KARAlPpNWYI) and [why vertical farms are moving beyond leafy greens (4:39)](https://www.youtube.com/watch?v=_tMVYxNRbMA).Describe how sensors, data, and automation can maximise agricultural yield.Identify information presented that can help with the design challenge.**Extension**Evaluate the potential biases in this video and identify further information that would be required to justify the use of vertical indoor farming.**Teacher and students**Explore webpages to find information about start-up indoor farming companies and the technologies used, for example:* [Modular farms Australia](https://www.modularfarms.com.au/)
* [Invertigro](https://www.invertigro.com/)
* [Iron ox](https://ironox.com/technology/).

**Students**Share what they have discovered and reflect on information and knowledge gained during the topic in respect to the design challenge, and evaluate resources and constraints, for example:* What is the challenge?
* What materials or technologies do we have access to?
* What are the time constraints?
 | Students can identify sources of information and explore existing solutions to create new design ideas. | Activate student prior knowledge by asking questions about previous learning relevant to indoor plant growth.Use closed captions when viewing video to assist understanding and vocabulary building. Review parts of the videos that describe specific construction steps and variables that are changed to maximise yield. |
| **Design****ST5-7, ST5-8**Students:* work individually or collaboratively to apply an engineering design process to complete a practical, real-world project-based learning task
* document design processes using engineering reports or design portfolio
* design solutions, synthesise ideas and plan.
 | **Teacher note**CAD drawings can be used for specific preparation for 3D printing or creating overall designs, for example:* upcycling old furniture or recycled materials for an indoor garden
* a 3D printed hydroponic or aeroponic system.

**Teacher**Demonstrate sketching or CAD.**Students**Create design ideas for possible solutions to the challenge. | Students produce drawings of design challenge solutions, for their portfolio, using demonstrated drawing techniques. | Model the use of sketching and CAD to communicate design ideas. |
| **Design****ST5-7, ST5-8**Students:* develop and evaluate creative, innovative, and enterprising design ideas and solutions to a range of problems.
 | **Teacher and students**Continuing creating and assessing design ideas.Begin to use their design and materials to complete the design challenge prototype. | Students have documented design solution sketches.Students produce a CAD drawing of their chosen solution. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**Complete weekly reflection by identifying and evaluating new knowledge or skills. | Students answer reflective questions, for example:* What did I learn about designing this week?
* When did I learn best?
 | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 6 – Prototype build****ST5-6**Students:* develop and evaluate creative, innovative, and enterprising design ideas and solutions to a range of problems
* prototype design solutions, for example
* rapid prototyping, models, simulation.
 | **Students****Use their design and materials to complete the design challenge prototype.****Teacher note****Conduct risk assessment before using equipment. Discuss the iterative process and highlight further build time after evaluation.****Teacher**Assist students in fabrication of their design using available resources, for example:* 3D printing
* laser cutting
* hand tools.
 | Students have constructed a physical prototype based on their CAD drawing or design sketch. | Actively assess student progress and assist where appropriate. |
| **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 prototypes this week?
* What did I enjoy doing this week?
 | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task. |

### Weeks 7 and 8

Table – Project-based learning weeks 7 and 8 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 7 – Evaluate****ST5-9**Students:* evaluate solutions, for example
* analyse data, critically reflect, plan revisions.
 | **Teacher**Review the role of evaluation in the engineering design process. Review different methods of evaluation, for example:* Strength, Weakness, Opportunity, Threat (SWOT)
* experimentation
* observation.

Review engineering design process evaluation questions with students, for example:* What revisions or improvements can be made to the design?
* Have safety requirements been met?

**Students**Complete a critical evaluation of their prototype or partially completed prototype. | Students document their evaluation on how successfully their prototype communicates their design solution.Students can answer evaluation questions, for example:* Has the solution produced any unintended outcomes?
* Can your design choices be justified?
* What was discovered from the testing and experimentation of the solution?
* Is there more experimentation and testing required?
* How well did the solution meet the success criteria?
 | Provide evaluation prompts or templates to scaffold evaluation.Provide evaluation example to demonstrate the process. |
| **Iteration****ST5-7**Students:* iterate designs, for example
* refine, redesign, prototype, minimal viable product
* demonstrate ability to communicate design ideas using a range of drawing techniques as described in the STEM fundamentals core topic.
 | **Teacher**Review the role of iteration in the engineering design process.Review engineering design process and iterate questions with students, for example:* Has the identified problem or need changed?
* How can the solution be further improved?
* If you decide to make revisions, what will it look like?
* Are there resources to make revisions?

**Students**Complete a critical evaluation of their prototype or partially completed prototype. | Students document their evaluation on how successfully their prototype communicates their design solution.Students demonstrate capacity to use evaluation to inform adaptation and iteration of their design. | Provide possible iteration questions or template to scaffold potential changes.Provide iteration example to demonstrate planning for changes. |
| **Problem solving****ST5-8**Students:* communicate solutions to problems through information communication technologies.
 | **Teacher and students**Workshop possible solutions to identified arising problems. Give constructive feedback and possible problem-solving ideas to students. | Students demonstrate capacity to communicate adaptation and iteration of their design. | Model the evaluative process, demonstrating the communication of evaluation and iteration of a design. |
| **Weekly reflection** | **Students**Complete weekly reflection by identifying and evaluating new knowledge or skills. | Students answer reflective questions, for example:* What did I learn about evaluation this week?
* When did I learn best?
 | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 8 – Build****ST5–1**Students:* develop and evaluate creative, innovative, and enterprising design ideas and solutions to a range of problems.
 | **Students****Use their evaluation to complete their design challenge build.****Teacher****Assist students in fabrication of design using available resources.****Teacher and students****Test design solution against design challenge criteria.** | Students have constructed a physical product based on their CAD drawing or design sketch.Students document the results of testing the design solution against success criteria. | Actively assess student progress and assist build where appropriate. |
| **Weekly reflection** | **Students**Complete weekly reflection by identifying and evaluating new knowledge or skills. | Students answer reflective questions, for example:* What did I learn about building this week?
* When did I learn best?
 | Modelling of the reflective process may assist with this task. |

### Weeks 9 and 10

Table – Project-based learning weeks 9-10 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 9 – Communicate****ST5-8**Students:* communicate and share solutions
* communicate solutions to problems through information communication technologies
* investigate and evaluate entrepreneurial mindsets and processes, for example
* critical thinking, flexibility and adaptability, communication and collaboration, calculated risk taking, initiative and self-reliance, creativity, and innovation
* idea generation and pitching, decision making
* seek expert advice and support on design and evaluation of innovative 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:* [shark tank edible cutlery (11:37)](https://www.youtube.com/watch?v=EU96s14zgLk)
* [calf catcher (2:54)](https://www.youtube.com/watch?v=3-5F-83W9nc)
* [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)
* [Steve Jobs (7:00)](https://www.youtube.com/watch?v=keCwRdbwNQY)
* [Space X (1:52)](https://www.youtube.com/watch?v=A0FZIwabctw).

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- to 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:* communicate solutions to problems through information communication technologies.
 | **Teacher**Review the creation of a design pitch.**Students**Continue to create their design pitch video. | Students can articulate the role of a pitch to communicate a design solution.Students produce a pitch that communicates their design solution. | Actively assess student progress with their pitch and assist where appropriate. |
| **Feedback****ST5-8*** communicate and share solutions
* communicate solutions to problems through information communication technologies.
 | **Teacher**Organise a shared digital space for students to post their pitch videos.**Students**Watch peers’ pitch videos and provide constructive feedback on written notes for other students.Submit feedback to teacher.**Teacher**Preview submitted 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.
 | (Add adjustments and registration) |
| **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?
* When did I learn best?
* What did I enjoy doing this week?
 | Procedural recount to be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 10 – Innovation****ST5-2**Students:* investigate organisations who produce innovative solutions and evaluate their processes.
 | **Teacher and students**Investigate organisations who produce innovative solutions and evaluate their processes, for example:* [How Apple is Organized for Innovation (4:35)](https://www.youtube.com/watch?v=5hENFA3CJUY)
* [7 urban agricultural start-ups worth keeping an eye on](https://www.siliconrepublic.com/start-ups/urban-agriculture-vertical-farming-startups)
* [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 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. |
| **Commercialisation****ST5-2, ST5-10**Students:* investigate and evaluate entrepreneurial mindsets and processes
* identify the types of STEM professions that would be required for the commercialisation of a design solution.
 | **Teacher**Briefly describe commercialisation of a prototype. Explain the role of investment in the commercialisation of a product.Present [How to Manufacture a Product (11:26)](https://www.youtube.com/watch?v=SD5e4XdyvV4). Identify and describe steps in the commercialisation process, for example:* marketing
* engineering
* manufacturing
* patents and intellectual property
* financing and accounting.

**Teacher and students**Engage with chapters 1, 3 and 5 of the [Entrepreneur workbook [PDF 1.78MB]](http://stelr.org.au/wp-content/uploads/2018/07/Entrepreneur-Workbook.pdf).Describe entrepreneurship, intellectual property, and entrepreneurial skills. | Students can identify steps in the commercialisation process.Students can define intellectual property and the importance of understanding intellectual property laws. | Use closed captions when viewing video to assist understanding and vocabulary building. Review parts of the videos that describe specific steps in the manufacturing process.Provide questions to help students identify and describe parts of the manufacturing process.Model strategies that assist understanding when reading the workbook, for example:* explicit breakdown of titles, headings, and keywords
* modelling or prompting answers to questions.
 |
| **Entrepreneurship****ST5-2, ST5-10**Students:* identify the types of STEM professions that would be required for the commercialisation of a design solution.
 | **Teacher and students**Complete desired chapters in the [Entrepreneur workbook [PDF 1.78KB]](http://stelr.org.au/wp-content/uploads/2018/07/Entrepreneur-Workbook.pdf) from last lesson.Evaluate the entrepreneurial profiles in the workbook to determine pathways to different entrepreneurial careers. | Students can evaluate entrepreneurial mindsets and processes.Students can describe some pathways into entrepreneurial careers. | Joint reading of workbook to assist with understanding. |
| **Weekly reflection** | **Students**Complete reflection by identifying and evaluating new knowledge or skills. | Students answer reflective questions, for example:* What did I learn about problem solving in this topic?
* What did I enjoy about this topic?
 | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task. |

## Additional information

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

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

### Assessment for learning

Possible formative assessment strategies that could be included:

* Learning intentions and success criteria assist educators to articulate the purpose of a learning task to make judgements about the quality of student learning. These help students focus on the task or activity taking place and what they are learning and provide a framework for reflection and feedback. [Online tools](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/622) can assist implementation of this formative assessment strategy.
* Eliciting evidence strategies allow teachers to determine the next steps in learning and assist teachers in evaluating the impact of teaching and learning activities. Strategies that may be added to a learning sequence to elicit evidence include all student response systems, [exit tickets](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/543), mini whiteboards (actual or [digital](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/575)), [hinge questions](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/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.

**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**: 15 November 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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