# iSTEM – Critical Problem-Solving



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## Critical Problem-Solving

Critical problem-solving involves objective analysis and evaluation of issues in order to form judgments which allow solutions to complex issues, or challenges to be rationally developed.

The ability to think critically and solve complex problems has been identified by many industries as some of the most highly desirable skills. A workforce with critical problem-solving skills is an enabler to engage with complex problems facing humanity.

This topic develops students’ ability to verify accurate information, analyse arguments, separate fact from fallacy, think independently and purposefully, solve problems creatively, and make informed decisions. To satisfy the requirements of this topic, students must utilise critical thinking skills and undertake a range of problem-solving exercises using problem-based learning strategies.

### Duration of learning

Indicative time – 25 hours.

### 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, 2021 for and on behalf of the crown in the State of New South Wales (2021).

## 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 [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).

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).

To meet the needs, interests, and abilities of students in the cohort, activities may be adapted or adjusted for the local context. When selecting alternate stimuli or issues for study, it is important to ensure compliance with the [Controversial Issues in Schools](https://education.nsw.gov.au/policy-library/policies/pd-2002-0045) policy.

### Weeks 1 and 2

Table 1 – Critical problem-solving weeks 1 and 2 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 1 – Lesson 1****ST5-2, ST5-5**Students define critical thinking and complex problem-solving. | **Teacher**Introduce the topic Critical thinking and complex problem-solving.Pose relevant real-life questions to students, for example: ‘Which mobile phone should I purchase?’**Teacher and students**Discuss factors that will affect the decision-making process, for example:* What is my budget?
* What products are available?
* What features are my ‘must haves’?
* What features are my ‘would like’?

**Students**Communicate and justify answers to original and subsequent questions.**Teacher and students**Identify and assess the factors that influence their choices.Discuss and explore reasons for answers and choices made to identify their decision-making process. Apply Socratic questioning to help students assess their research and decisions, for example:* Could you explain your reason to us?
* Has your opinion or decision been influenced by something or someone?
* Where did you get those ideas?

**Teacher****Briefly describe credibility, bias, and validity of different information sources and how that may have influenced decision making.**Link class activity to critical thinking, decision-making, and complex problem-solving.Explicitly identify steps taken by students during the activity, for example:* identifying the parameters of the problem
* investigating options
* evaluating ideas
* assessing information sources
* making decisions.
 | Students can either independently create decisions or contribute to group or class decisions.Students use a journal for this topic. Part of this journal entry includes the resources used to gather information, the thinking behind the decision making, and the evaluation of research.Journal entries focus on capturing the evolution of a student’s ideas whilst they discover new information. Students begin to discover that ideas can change in the light of new evidence or information.Students record some steps taken to arrive at their decision, for example:* identifying the parameters of the problem
* investigating options
* evaluating ideas
* assessing information sources
* making decisions.
 | Students with social anxiety may not feel comfortable partaking in a face-to-face group activity but may be comfortable with using an online blog or chat. This may require the whole class using the chat function to enhance inclusivity. Adjust learning activities based on individual student learning needs.Create a joint journal entry to model this process for students.Students may benefit from a list of specific sites and examples that the teacher believes is appropriate for their context, student cultures, and questions. |
| **Week 1 – Lesson 2****ST5-2, ST5-5**Students investigate a range of problem-solving and decision-making strategies. | **Teacher****Review decision-making process from previous lesson.****Teacher and students**Explore published problem-solving and decision-making strategies.Provide sample sites for students to explore and compare with the steps provided, for example:* [Problem-solving techniques](https://www.sessionlab.com/blog/problem-solving-techniques/)
* [Problem-solving steps and methods](https://credentials.deakin.edu.au/problem-solving-techniques-steps-and-methods/).

Identify common steps used in problem-solving and decision making.**Teacher**Highlight the assortment of strategies identified and discuss the benefits of diverse thinking.Model journal entries and reflect upon the evolution of a person’s ideas as information is discovered and processed. | Students use a journal for this topic. Journal entries include the resources used to gather information, the different processes that may have been found, and the potential comparisons between different sources.Journal entries focus on capturing the evolution of a student’s ideas whilst they discover new information. Students that identify ideas can change in the light of new information or from looking at information from a different perspective. | Scaffold, or pre-teach, problem-solving steps to introduce terminology and concepts, for example:* defining the problem
* investigate existing facts or ideas
* evaluate the outcome
* adapt the solution.

Provide sample sites for students to explore and compare with the steps provided, for example:* [Problem-solving techniques](https://www.sessionlab.com/blog/problem-solving-techniques/)
* [The Six Step Problem Solving Model](http://www.free-management-ebooks.com/news/six-step-problem-solving-model/)
* [Problem-solving steps and methods](https://credentials.deakin.edu.au/problem-solving-techniques-steps-and-methods/).
 |
| **Week 1 – Lesson 3****ST5-2, ST5-5**Students investigate a range of problem-solving and decision-making strategies. | **Teacher and students**Review common themes, ideas, or steps published on problem-solving and decision-making strategies found in the last lesson.Compare an older resource ‘[The Effective Decision’](https://hbr.org/1967/01/the-effective-decision) and a newer resource ‘[Problem-solving’](https://www.healthywa.wa.gov.au/Articles/N_R/Problem-solving).**Teacher**Explain that there may be alternative ways to specifically address a problem or decision. While specific terminology may differ, the general principles are similar.Review the purpose of reflection.Review how to complete a reflection using a procedural recount text type, for example:* describe the tasks and what happened
* identify what you learnt or observed
* evaluate new knowledge in the context of previous knowledge
* analyse key insights.
 | Journal entries focus on capturing the evolution of a student’s ideas whilst they discover new information. Students discover that ideas can change in the light of new evidence or information.Students demonstrate an understanding of different problem-solving and decision-making processes.Students demonstrate an ability to reflect on their learning and the changing nature of ‘knowledge’. | Explicit review of problem-solving steps from last lesson will allow frontloading of vocabulary and concepts in this lesson.Explicit teaching in this lesson can involve teachers selecting key parts of both texts for students to focus on and joint reading text with students, for example:* joint reading and deconstruction of text 1, ‘Sequential Steps’.
* joint reading of text 2, ‘Design flow process’ and explicit linking of the visual on page 926 with text on page 927.
 |
| **Week 1 reflection** | **Students**Assess what they have learnt, what it means and how they learn.Complete weekly reflections 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 will be able to record their key learning events or activities using a journal.Students will demonstrate the impact of these learning events or activities by making judgments about what has happened and how they believe they learn effectively.Students answer reflective questions, for example:* What did I learn about creative problem-solving this week?
* Why is creative problem-solving important?
* When was I at my best this week, and why?
* Did I learn best when researching, applying, or discussing ideas?
 | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 2 – Lesson 1****ST5-2, ST5-5**Students:* critically assess and evaluate information
* identify common principles that hinder critical thinking, for example: confirmation bias, heuristics, framing, and common fallacies.
 | **Teacher and students****Read ‘**[Hundreds of fish species, including many that humans eat, are consuming plastic’](https://theconversation.com/hundreds-of-fish-species-including-many-that-humans-eat-are-consuming-plastic-154634)**.****Discuss the article and identify how information can be presented in certain ways to achieve certain goals.****Discuss terms such as bias, authority and credibility. Identify the authority and credibility of the authors, and potential bias.****Students**Investigate and analyse information and secondary sources surrounding different types of renewable energy projects, for example:* the [Sun Cable](https://suncable.energy/) project
* [IRENA](https://www.irena.org/newsroom/pressreleases/2022/Apr/Renewables-Take-Lions-Share-of-Global-Power-Additions-in-2021).

**Teacher and students**Assess the information sources and identify potential bias, objectivity, argumentation, authority, and credibility of the sources, for example:* What facts does the author use?
* What words create positive or negative impressions?
* What impression would I have if I switch certain words?
* Who is paying for the website?
* Are different points of view expressed?
* What is the purpose of the publication?
 | Students can describe how information can be presented to influence an audience. Students can give examples from both resources.Students have documented their research and discussion on the impact of bias in their journal with specific examples from the text. | Collaborative investigation of secondary sources can support student understanding and participation, for example:* joint reading of the [Sun Cable](https://suncable.energy/) project website homepage
* joint viewing of the [Sun Cable video (2:46)](https://suncable.energy/).

Use closed captions when viewing video to assist understanding and vocabulary building. |
| **Week 2 – Lesson 2****ST5-6**Students:* assess the logic and validity of arguments
* critically assess and evaluate information, for example
* bias, authority and credibility, timeliness, relevance of sources, validity
* primary sources and secondary sources.
* identify common principles that hinder critical thinking, for example: confirmation bias, heuristics, framing, and common fallacies
* apply critical thinking methodologies, for example, Socratic questioning, oral and written reflection.
 | **Teacher and students**Critically assess information sources to identify potential bias, argumentation, authority and credibility of the source. Examine secondary sources to identify potential cognitive biases, for example:* [Flicking the switch: (Hybrid) renewable energy comes to Flinders Island (2:45)](https://www.youtube.com/watch?v=kcwnv-MBQ_M&list=PLEtIWM856QquCM2Kde6ZrYdRZ2slP14JH&t=16s)
* [Renewable energy development threatens many globally important biodiversity areas](https://www.researchgate.net/publication/339715092_Renewable_energy_development_threatens_many_globally_important_biodiversity_areas).

Investigate these sources of information.Identify the following cognitive biases:* authority and credibility – are the authors or creators experts in their field?
* bias – is the author presenting information in a certain way to influence our thinking?
* confirmation bias – are we only listening to information that supports our theory or ideas?
* [heuristics [PDF 36.7KB]](http://fas-polisci.rutgers.edu/levy/articles/2002%20Kahneman.pdf) – are we unconsciously applying mental shortcuts or generalisations?
* framing – are we making decisions based on how information is presented? For example, would you buy ice cream that is labelled 2% fat or 98% fat free.

Discuss common fallacies that may arise in sources, for example:* *tu quoque* fallacy – are we ignoring information because the originator does not practice their advice? For example, ignoring the advice from a doctor who smokes or a personal trainer that does not exercise
* fallacious appeal to authority – are we relying on apparent authority to imply truth? For example, believing something just because a respected newspaper reports it
* composition fallacy – if a part of an argument is true, then the whole argument is true.
 | Students describe how information can be presented to influence an audience with specific examples.Students can recognise influence on their decision making.Students have documented their research and explore the impact of bias in their journal with specific examples from the text related to the cognitive biases discussed, for example:* authority and credibility – are we agreeing with something because it is popular or because it is well supported with evidence?
* bias – are we ignoring the big picture? Are we focusing on only a small section of information?
* confirmation bias – are we only listening to information that supports our theory or ideas?
* heuristics – is my thinking automatic or am I thinking critically about the situation?
* framing – could we draw a different conclusion if the information is presented in a different way?
* fallacies – am I unconsciously applying common fallacies?
 | Review key concepts and vocabulary before viewing video. Use closed captions and provide the transcript. Pause video to assess student understanding at appropriate points.Model strategies that assist understanding if reading complicated texts (research articles), for example:* explicit breakdown of titles, headings, and keywords
* read the conclusion in depth to understand the authors point of view and potential bias.
 |
| **Week 2 – Lesson 3****ST5-9**Students critically assess the design of data visualisations to effectively inform and persuade. | **Teacher****Present ‘**[How to spot a misleading graph’ (4:09)](https://www.youtube.com/watch?v=E91bGT9BjYk) **and describe key points.****Discuss that data visualisations can be presented in ways that support a certain argument, for example:*** **the scale of the y-axis can be changed to increase or decrease apparent differences between products**
* **the scale of the x-axis can be altered to highlight or hide certain trends.**

**Teacher and student****Critically assess graphs from documentaries, news broadcasts, newspapers, and advertisements.****Evaluate any arguments being represented and in what ways the data is being presented to support that argument.****Identify when data correlations are used to support causations.****Discuss issues with assuming correlations indicate causations.****Teacher**Explicitly divert data visualisation discussion to the use of electricity and energy generation. Introduce dynamic graphs on energy generation or use, for example:* [electricity generation in Australia](https://opennem.org.au/energy/nem/?range=7d&interval=30m)
* European hourly electricity mix’ on [WindEurope](https://windeurope.org/about-wind/daily-wind/electricity-mix).

**Teacher and student****Analyse the dynamic graph.****Teacher****Demonstrate how to apply various filters and instruct students to generate questions from exploring these graphs.****Students**In groups generate as many questions as they can and present on butcher’s paper or portable whiteboards.**Teacher and student****Discuss answers and choose questions for further study that are related to renewable energy themes that can be explored next lesson.** | Students describe how data can be presented to influence an audience. Students can give specific examples.Students explain specific ways graphs can be changed to influence an audience in their journal.Student questions are displayed on butcher’s paper or portable whiteboards, for example:* **What is the source?**
* **Who are the publishers?**
* **What is the purpose of the graph?**
* **Why are** there **fluctuations in different types of energy?**
* **Why does the Netherlands graph fluctuate so much?**
* **Why doesn’t Norway produce solar power?**
* **What does GW stand for?**
 | Using closed captions can assist access to video content.Message abundance can assist with understanding of concepts and vocabulary. Pause, and possibly replay the video at key moments to explicitly emphasise certain points, for example:* identify certain axes
* explain changes in scales
* evaluate the impact of scale changes
* discuss cherry-picking of data.
 |
| **Week 2 reflection** | **Students**Complete weekly reflections 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 cognitive bias this week?
* How does cognitive bias affect my decisions every day?
* Did I learn best when researching, applying, or discussing?
 | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 3 and 4

Table 2 – Critical problem-solving weeks 3 and 4 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 3 – Lesson 1****ST5-9, ST5-10**Students:* use evidence and scientific reasoning to produce rational solutions to problems
* apply critical thinking methodologies, for example, oral and written reflection, and argumentation.
 | **Teacher and students****Review the energy mix questions from the last lesson.****Teacher****Assign electricity mix questions to student groups for investigation. Use questions that cover the following energy types: solar, wind, lignite, nuclear, hydro, and gas.****Students****Groups investigate assigned questions related to different electricity supplies.****Research the question, evaluate the information, and produce answers that they present to the class in the next lesson.** | Students document research in their journals.Students demonstrate information research skills and capacity to synthesise information into a cohesive presentation. | Scaffold activity to assist students, if required, or model the research process to enhance understanding of the activity. |
| **Week 3 – Lessons 2 and 3****ST5-10**Students:* use evidence and scientific reasoning to produce rational solutions to problems
* apply critical thinking methodologies, for example, oral and written reflection, and argumentation.
 | **Students**Groups present answers to their electricity source question**.****Teacher and students****Reflect on answers presented to the class and discuss information relating to the future of electricity supplies.****Teacher**Lead class discussion and introduce smaller scale electricity production in preparation for the next lesson**.** | Students document research in their journals.Students demonstrate information research skills and capacity to synthesise information into a cohesive presentation.Students demonstrate communication skills. | Students may not be able to present information verbally. An electronic method for the whole class to share presentations may be utilised, for example:* PowerPoints that have voice recording
* PowerPoints that have comprehensive notes and no voice recording.

Adjust learning activities based on student individual learning plans. |
| **Week 3 reflection** | **Students**Complete weekly reflections 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 energy sources this week?
* How was my thinking affected by the information presented?
* Do I agree with the information?
* Did I learn best when working independently, or when working in a group?
 | Modelling of the reflective process may assist with the metacognitive (thinking about thinking) aspects of this task.Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 4 – Lesson 1****ST5-10**Students:* develop and evaluate creative, innovative, and enterprising solutions to problems
* use evidence and scientific reasoning to produce rational solutions to problems
* apply critical thinking methodologies, for example, Socratic questioning, oral and written reflection, and argumentation.
 | **Teacher and students****Explore smaller scale renewable electricity systems such as solar (panels, tiles, fabrics), compact wind turbines, or micro-hydro power systems, for example:*** **What systems are available?**
* **What are the benefits and limitations of each system?**
* **What potential costs are associated with each system?**
* **What system would be best for different situations?**

**Discuss information regarding small scale renewable systems, for example:*** **Which systems are better for residential or commercial enterprise?**
* **What factors would need to be accounted for when considering which system is most appropriate for a certain location?**

**Teacher**Use discussion and visuals to transition into the upcoming inquiry lessons regarding solar cells. | Students can identify and describe different renewable electricity systems.Students can explain different benefits, limitations, risks, and costs associated with some systems.Students demonstrate capacity to evaluate renewable electricity systems in relation to environment or context.Students demonstrate understanding of cognitive biases utilised by authors of information and demonstrate techniques used to confirm information validity and reliability. | (Add adjustments, enhancements, and registration). |
| **Week 4 – Lesson 2****ST5-10**Students:* investigate the use of critical thinking and problem-solving in business and industry
* engage in industry career development opportunities to gain a deeper knowledge of real-world problem-solving, for example, mentors, work experience, excursions, incursions, industry groups, exhibitions, competitions.
 | **Teacher**Introduce careers that involve engineering and installation of renewable energy projects through primary or secondary sources, for example:* industry incursion or excursion
* ‘[day in the life’ (3:07)](https://www.youtube.com/watch?v=4oGo8P8CtJw) solar design engineer video.

**Teacher and students****Review and discuss factors that may affect solar power electricity generation and use for residential, commercial, or industrial situations, for example:*** **ambient temperature**
* **temperature of panels**
* **location or aspect.**

**Teacher**Use discussion and visuals to transition into the upcoming inquiry lessons. | Students can identify specific STEM careers that use STEM skills in their work. | Review key concepts and vocabulary before viewing video. Use closed captions and provide the transcript. Pause video to assess student understanding at appropriate points. |
| **Week 4 – Lesson 3****ST5-4, ST5-10**Students:* work individually or collaboratively to apply critical thinking and problem-solving strategies to design solutions to complex problems
* apply appropriate research models and methodologies to gather valid reliable data.
 | **Teacher and students****Conduct a confirmation inquiry to determine the maximum power output/voltage of a solar cell.** **The question and method for the inquiry is identified and explained. Students attempt to confirm the stated voltage for the solar cell.****Use a high lumen light source, multimeter, infrared thermometer, and 1.5V to 3V solar cell.****Determine the solar cell voltage under controlled or known conditions, for example:*** **light source**
* **distance from light source.**

**Compare class results to the stated maximum voltage of the solar cell. They do not match. Discuss possible variables that may affect the power output of the solar cell.****Teacher****Use discussion to transition into the next inquiry lesson regarding the effect of temperature on solar cells.**Explain the choice of measuring voltage as opposed to power.**Note**: Measuring voltage will reduce potential measurement errors in subsequent investigations. | Students demonstrate investigation skills required to conduct, analyse, and communicate investigations.Students complete and submit a scaffolded scientific report.Students demonstrate accurate use of multimeter. | Provide scientific report scaffold. Add examples to scaffold if required.Provide real-world photograph of inquiry method to assist understanding.Explicitly demonstrate the correct use and connection of a multimeter in this context. |
| **Week 4 reflection** | **Students**Complete weekly reflections 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 solar energy this week?
* Did I face any challenges within the activities, and how did I overcome them?
* Which activity did I enjoy the most and why?
 | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 5 and 6

Table 3 – Critical problem-solving weeks 5 and 6 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 5 – Lesson 1****ST5-4, ST5-8**Students:* work individually or collaboratively to apply critical thinking and problem-solving strategies to design solutions to complex problems
* apply appropriate research models and methodologies to gather valid reliable data
* develop and evaluate creative, innovative, and enterprising solutions to problems
* use evidence and scientific reasoning to produce rational solutions to problems
* create visual representations of data to support evidence-based decision making.
 | **Teacher and students****Conduct a structured inquiry to determine if temperature affects the voltage of a solar cell.****Teacher****Explain the question and method to students.****Provide a coherent method with some key information missing so that students can critique method, for example:*** **time between placing cell on cold pack and taking measurements**
* **exact placement of cell compared to light source.**

**Students****Use a consistent lumen light source, multimeter, infrared thermometer, hot/cold pack, and 1.5V to 5V solar cell.****Determine the solar cell voltage under varied temperature conditions.****Measure the surface temperature of the solar cell at the same point with an infrared thermometer in different temperature conditions and record multiple voltage values for each temperature condition.****Note**: See [‘Solar cell power output vs. temperature’](https://www.sciencebuddies.org/science-fair-projects/project-ideas/Energy_p012/energy-power/solar-cell-power-output-versus-temperature) for more information on experimental setup. | Students demonstrate investigation skills required to conduct, analyse, and communicate investigations.Students demonstrate capacity to write scientific report.Students discover the problematic nature of this investigation and develop methods to attempt to enhance reliability, accuracy, and validity, for example:* How long should we wait when we place the cell on the cold/hot pack?
* How do we maintain a consistent distance from the light source?
* Is the light source consistent?
* Does it matter where we measure the temperature?
* Is the thermometer working properly?
* Is the multimeter accurate?
* Is the solar cell functioning?
 | Provide scientific report scaffold. Add examples to scaffold if required.Provide real-world photograph of inquiry method to assist understanding.Explicitly review the correct use and connection of a multimeter in this context. |
| **Week 5 – Lesson 2****ST5-4, ST5-8**Students:* develop and evaluate creative, innovative, and enterprising solutions to problems
* use evidence and scientific reasoning to produce rational solutions to problems
* apply appropriate research models and methodologies to gather valid reliable data
* create visual representations of data to support evidence-based decision making.
 | **Teacher and students****Continue structured inquiry to determine if temperature affects the power output of a solar cell.****Teacher**Model the analysis of results from the inquiry using a spreadsheet program.**Students**Create a simple column graph using the mean of the cold, warm, and hot groups.**Teacher and students**Change the minimum and maximum bounds of the y-axis. Evaluate the effect of this formatting change on the perceived differences between the groups.Create a line graph using temperature and voltage measurements.Compare column graph and line graph.Determine if the data set is discrete, continuous, or both depending on the handling of the data.Evaluate which graph could be used for different situations. | With assistance students complete and submit a scientific report.Students demonstrate capability to create data visualisations.Students identify limitations and propose improvements to investigation.Students demonstrate capacity to critically analyse different data visualisations and propose data sets and situations when they would be used. | Provide scientific report scaffold. Add examples to scaffold if required. Model the use of the scientific report template.Model the use of spreadsheet programs for data analysis, the calculation of mean values, and the creation of graphs. |
| **Week 5 – Lesson 3**Students:* create visual representations of data to support evidence-based decision making
* use statistics and probability to analyse data and support decision making, for example, standard deviation
* explore statistical functions of spreadsheets and/or graphing calculators.
 | **Teacher and students**Continue analysis of results from the inquiry and discuss the term standard deviation (SD).Students calculate the standard deviation manually for the cold, warm, and hot groups.Students then use a spreadsheet program to calculate the SD.Students add labels to their column graphs showing the mean and the SD.**Students produce a box and whisker graph for their cold, warm, and hot data. Teachers explain what the chart represents and discusses the value of this visualisation.****Complete scientific report using data visualisations created.** | Students understand the efficiencies software programs can provide.With assistance, students can accurately utilise a spreadsheet program to analyse data and produce visualisations for their scientific report. | Model the calculation of standard deviation and creation of the graph.Provide a pre-prepared spreadsheet to scaffold data entry and automate analysis. |
| **Week 5 reflection** | **Students**Complete weekly reflections 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 investigations and data analysis this week?
* Did I learn skills this week and are they important?
* Did I face any challenges, and how did I overcome them?
* Did I prefer the investigation, or working on spreadsheets?
 | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 6 – Lesson 1****ST5-9**Students:* use statistics and probability to analyse data and support decision making, for example, correlation
* explore statistical functions of spreadsheets and/or graphing calculators
* investigate software and computing technologies to simulate and/or analyse data in contemporary business and industry contexts for the purposes of making data-informed recommendations.
 | **Teacher and students****Assess publicly available full text** [scientific journal publications](https://www.researchgate.net/publication/266593060_Effects_of_Ambient_Temperature_on_the_Performance_of_a_Photovoltaic_Solar_System_in_a_Tropical_Area) **that investigated ambient temperature effects on the power output of a solar cell.****Assess possible limitations in the publication.****Explicitly analyse the use of the correlation coefficient (r) in the example publication. Discuss the importance of the r value when analysing the results of an investigation.****Teacher****Emphasise the importance of viewing statistics within the context of the investigation.** | Students can identify key features of the method employed by the researchers.Students can summarise the research and the results.Students can identify limitations in the publication and generate questions, for example:* **Is the temperature range related to the amount of solar radiation?**
* **Would this affect results?**
* **Why or why not?**
* **What other variables could we record?**

Students can describe the use of the correlation coefficient and identify it as a statistical tool they can use in their research. | (Add adjustments, enhancements, and registration). |
| **Week 6 – Lesson 2****ST5-9**Students:* use statistics and probability to analyse data and support decision making, for example
* correlation, reliability, significance.
* explore statistical functions of spreadsheets and/or graphing calculators
* investigate software and computing technologies to simulate and/or analyse data in contemporary business and industry contexts for the purposes of making data-informed recommendations.
 | **Teacher and students**Students use their own data set to produce a scatter plot, linear trend line, trend line equation, and R² value.Present ‘[How To Perform Simple Linear Regression In Excel’ (14:50)](https://www.youtube.com/watch?v=9wX1a1J4WOI) and utilise Microsoft Excel’s ‘Analysis ToolPak’ add-in to produce simple linear regression correlation statistical values r, R² and p.Discuss statistical outputs and evaluate the importance of it in relation to data analysis, communicating results, and decision making. | With assistance, students can accurately utilise a spreadsheet program to analyse data and produce visualisations for their scientific report. | Pause, and possibly replay, the video at key moments to ensure process can be followed. Slow and steady progress is advised.Use closed captions to assist access to video content. Provide transcript to assist with understanding and recall.Provide example spreadsheet using different data to model the desired output.Some students may require adjustments to participate in classroom discussions. |
| **Week 6 – Lesson 3****ST5-9**Students:* apply appropriate research models and methodologies to gather valid reliable data
* create visual representations of data to support evidence-based decision making.
 | **Students****Use results from temperature inquiry and the equation for the line of best fit to calculate the predicted voltage at a solar cell temperature of 60 degrees Celsius.****Repeat their temperature inquiry to evaluate if the linear regression has allowed for accurate inference of voltage at 60 degrees Celsius.** | Students accurately use equation for line of best fit to calculate predicted voltage.Students successfully recreate methodology and undertake investigation to assess inference accuracy.Students identify the importance of having a reproducible methodology and appreciate the rationale behind scientific reports. | (Add adjustments, enhancements, and registration). |
| **Week 6 reflection** | **Students**Complete weekly reflections 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 data analysis this week?
* Why is it important to thoroughly analyse data?
* Did I learn best doing the activities, discussing the activities, or both?
 | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 7 and 8

Table 4 – Critical problem-solving weeks 7 and 8 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 7 – Lessons 1, 2, and 3****ST5-1, ST5-2, ST5-4, ST5-6, ST5-7, ST5- 8, ST5-9**Students:* work individually or collaboratively to apply critical thinking and problem-solving strategies to design solutions to complex problems
* apply appropriate research models and methodologies to gather valid reliable data
* develop and evaluate creative, innovative, and enterprising solutions to problems
* use evidence and scientific reasoning to produce rational solutions to problems
* create visual representations of data to support evidence-based decision making
* use statistics and probability to analyse data and support decision making, for example, standard deviation, correlation
* explore statistical functions of spreadsheets and/or graphing calculators.
 | **Teacher and students****Conduct a guided inquiry to determine how changes in incoming light intensity affects the output of solar cells.****Teacher****Explain the question for the inquiry.****Support students in planning their own method and conducting their own inquiry.****Provide encouragement and guidance to students, and only if safe to do so, allow for ‘mistakes’ in methodology to occur. Provide a wide range of safe materials that students may use in their inquiry.****Students****Groups communicate, research, plan, requisition materials, conduct investigation, analyse results, and communicate their findings using a scientific report template.****Teacher and students**Create graphical representations and statistical functions on spreadsheet programs to calculate mean and standard deviations, and create column graphs. Create scatter plot graphs and determine correlations. Select the most appropriate visualisations to represent the data.**Note**: See ‘[How Does Solar Cell Output Vary with Incident Light Intensity?](https://www.sciencebuddies.org/science-fair-projects/project-ideas/Energy_p014/energy-power/how-does-solar-cell-output-vary-with-incident-light-intensity)’ for more information on experimental setup. | Students demonstrate investigation skills required to plan, conduct, analyse, and communicate investigations.Students can effectively use a scientific report template.Students can plan, conduct, and communicate a valid methodology for their investigation.Students can accurately use a spreadsheet program to analyse data and produce visualisations for their scientific report. | Provide scientific report scaffold. Add examples to scaffold if required. Model the use of the scientific report template.Review the use of Microsoft Excel for data analysis, the calculation of mean values and the creation of graphs. |
| **Week 7 reflection** | **Students**Complete weekly reflections 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 investigations and data analysis this week?
* Did I face problems this week, and what steps did I take to solve problems that I faced?
* Did I discuss problems with my team members?
* Was I open to new ideas?
 | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 8 – Lessons 1, 2, and 3****ST5-1, ST5-2, ST5-4, ST5-6, ST5-7, ST5- 8, ST5-9**Students:* apply critical thinking and problem-solving strategies to analyse, develop and evaluate solutions
* work individually or collaboratively to apply critical thinking and problem-solving strategies to design solutions to complex problems
* demonstrate innovation and entrepreneurial activity and communicate solutions.
 | **Students****Conduct a guided inquiry to determine how a solar cell angle, in relation to a light source, affects the voltage of solar cells.****Teacher****Identify and explain an inquiry question.****Support students in planning their own method and conducting their own inquiry.****Provide a wide range of safe materials that students may use in their inquiry.****Take the role of a safety officer and facilitator during the inquiry.****Students****Student groups discuss, research, plan, requisition materials, conduct investigation, analyse results, and communicate their findings.** | Students should demonstrate investigation skills required to plan, conduct, analyse, and communicate investigations.Students can effectively use a scientific report template.Students can plan, conduct, and communicate a valid methodology for their investigation.Students can accurately use a spreadsheet program to analyse data and produce visualisations for their scientific report.Students submit completed scientific report. | (Add adjustments, enhancements, and registration). |
| **Week 8 reflection** | **Students**Complete weekly reflections 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 the scientific method this week?
* Did I think critically about the question and my method?
* What skills did I apply during this challenge, and how are those skills important to my possible future career?
 | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 9 and 10

Table 5 – Critical problem-solving weeks 9 and 10 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 9 – Lesson 1****ST5-5**Students:* investigate the use of critical thinking and problem-solving in business and industry
* investigate factors and decisions which result in successful and failed business ventures
* investigate entrepreneurial mindsets and processes, for example, flexibility, adaptability, communication and collaboration, risk taking, initiative, self-reliance, creativity, innovation.
 | **Teacher and students**Examine the situation documented in [The Hwang Scandal That “Shook the World of Science”](https://www.tandfonline.com/doi/full/10.1215/s12280-008-9041-x) and [Timeline of a controversy](https://www.nature.com/news/2005/051219/full/news051219-3.html).Summarise the claims made and discuss the issue of possible data fabrication, research fraud, and ethics breaches.Apply knowledge of cognitive bias to critically assess and evaluate these information sources. | Students can define terms such as data fabrication, research fraud, and ethics breaches.Students can identify the role of peer review to critically examine the publications from colleagues and experts as a method to attempt to seek reliability, validity, and accuracy from secondary sources of information. | (Add adjustments, enhancements, and registration). |
| **Week 9 – Lesson 2****ST5-5**Students investigate factors and decisions which result in successful and failed business ventures.  | **Teacher and students**Examine the failed business venture in [Theranos: Almost Complete Absence of Laboratory Medicine Input](https://academic.oup.com/jalm/article/3/5/749/5603092) and [False dawns: implications for patients of the Theranos debacle](https://www.bmj.com/content/376/bmj.o178?utm_source=trendmd&utm_medium=trendmd&utm_campaign=institutional&utm_content=BMJUK_TMD_CM_2022&utm_term=tbmj).Summarise the claims made and discuss the potential problems that occur when proprietary technology does not undergo critical peer review.Apply knowledge of cognitive bias to critically assess and evaluate these information sources. | Students can identify the importance of critical analysis of publications.Students describe steps that are used to verify the accuracy of claims made by authors.Students can explain why critical review is difficult within areas of proprietary claims made by businesses. For example: a business may rely on having a proprietary product, but the claims of the product need to be verified or tested for safety or efficacy reasons. | (Add adjustments, enhancements, and registration). |
| **Week 9 – Lesson 3****ST5-5**Students:* investigate the use of critical thinking and problem-solving in business and industry
* investigate factors and decisions which result in successful and failed business ventures.
* investigate entrepreneurial mindsets and processes, for example flexibility, adaptability, communication and collaboration, risk taking, initiative, self-reliance, creativity, innovation.
 | **Teacher and students**Examine videos, news reports and articles of successful [STEM businesses](https://www.chiefscientist.nsw.gov.au/events/national-science-week-in-nsw/growing-sustainable-nsw-businesses-with-stem).Identify and describe the businesses.Explain the problem that the business faced and the solution that the business deployed/created.Identify the entrepreneurial mindset/s the business embraced to develop innovative solutions. | Students can describe factors that can lead to successful STEM businesses.Students can identify problems and innovative solutions.Students can identify entrepreneurial mindset in businesses, for example:* flexibility
* adaptability
* communication and collaboration
* risk-taking
* initiative
* creativity
* innovation.
 | (Add adjustments, enhancements, and registration). |
| **Week 9 reflection** | **Students**Complete weekly reflections 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 businesses this week?
* Why is it important to be critical of claims made by entrepreneurs?
* What entrepreneurial skills do I believe are most important, and why?
 | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 10 – Lesson 1****ST5-10**Students:* investigate the use of critical thinking and problem-solving in business and industry
* investigate factors and decisions which result in successful business ventures.
 | **Teacher**Present careers with high demand for STEM skills and critical problem-solving.Present students with [STELR women in STEM](https://stelr.org.au/womeninstem/) website link.**Students**Explore the STELR renewables engineer profile of [Sheena Ong (3:13)](http://stelr.org.au/career_profiles/sheena-ong/) and at least 2 other videos and career profiles of personal interest. Investigate the nature of work undertaken and the pathways into professions which utilise STEM skills. | In their journals, 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, enhancements, and registration). |
| **Week 10 – Lesson 2**Students investigate entrepreneurial mindsets and processes, for example, flexibility, adaptability, communication and collaboration, risk-taking, initiative, self-reliance, creativity, innovation. | **Teachers****Present** [women in STEM entrepreneurship](https://australiascience.tv/theme/women-in-stem/) **website along with** [STEM Entrepreneurs (3:00)](https://australiascience.tv/episode/stem-entrepreneurs/) **and** [Liz Williams and Kate Lomas profile (2:32)](http://stelr.org.au/career_profiles/kate-lomas-and-liz-williams/)**.****Teachers and students****Identify and describe the entrepreneurial skills and mindsets that students have exercised during this module.****Explain the benefits of having an entrepreneurial mindset when undertaking critical problem-solving.** | Students identify and describe different skills and mindsets that are beneficial to STEM and critical problem-solving.Students undergo self-reflection in relation to a career they would like to possibly pursue and can describe pathways to different STEM careers. | (Add adjustments, enhancements, and registration). |
| **Week 10 – Lesson 3****ST5-3**Students:* apply critical thinking and problem-solving strategies to analyse, develop and evaluate solutions
* work individually or collaboratively to apply critical thinking and problem-solving strategies to design solutions to complex problems.
 | **Teacher and students**Reflect on summaries from week 1 regarding the topic critical thinking and complex problem-solving.Discuss student reflections and evolution of ideas through this topic.Compare student summaries to the engineering design process. | Students articulate the evolution of their ideas regarding critical thinking and problem-solving.Students can find similarities and differences between the engineering design process and the critical thinking, problem-solving, and investigation processes undertaken.Students can identify that critical problem-solving may help to structure a problem, disaggregate it into solvable parts, prioritise the critical aspects, and then design analyses to lead to a solution. This is like the engineering design process but in the engineering design process, we may also build prototypes, test them, then redesign them. | (Add adjustments, enhancements, and registration). |
| **Week 10 reflection** | **Students**Complete weekly reflections 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 businesses this week?
* Why is it important to be critical of claims made by entrepreneurs?
* What entrepreneurial skills do I believe are most important, and why?
 | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |

## Reflection and evaluation

Reflecting on and evaluating learning activities should be an ongoing process that happens throughout the delivery of this topic. Teachers should document their evaluation of learning activities throughout the program. The space provided below is to reflect on and evaluate the overall unit of work.

## 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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