# iSTEM – sustainable transport



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## Sustainable transport

Transport systems that are economically and operationally resilient, and environmentally and socially sustainable are highly desirable. They create liveable places, foster productive economies, reduce congestion and emissions, and support equity and the wellbeing of our communities.

In this specialised topic, students will develop skills, knowledge and understanding of sustainability and sustainable transport by completing a range of inquiry-based and problem-based learning tasks. Students will explore current issues facing the transport sector and how current and emerging technologies can be designed, constructed, and evaluated to provide solutions to real-world challenges.

### 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.

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

### Rationale

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

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

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

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

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

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

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

### Aim

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

### Purpose and audience

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

### When and how to use this document

Use this resource when designing learning activities that align with the course outcomes and content. The activities and resources can be used directly or may be adapted based on teacher judgment and knowledge of their students. 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 for adjustments and enhancements that are made to the learning sequence during its implementation, in order to meet the individual needs of students and to allow for differentiation of the iSTEM curriculum. For further advice, see [Additional information](#_Additional_information) in this document.

### Weeks 1 and 2

Table 1 – sustainable transport weeks 1 and 2 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 1 – introduction**  **ST5-10**  Students:   * investigate changes to energy sources over time in the transport industry * explain the sustainability hierarchy associated with regards to transportation and emissions. | **Teacher**  Outline the sustainable transport topic and describe the tasks to be completed:   * investigation of battery electric vehicle technologies * parking system prototype * presentation of parking system solution.   Explain the [sustainable travel hierarchy](https://energysavingtrust.org.uk/an-introduction-to-the-sustainable-travel-hierarchy/) with regards to transportation, emissions and changes to available energy sources.  **Students**  Describe the sustainable transport hierarchy and how it is influenced by both waste and energy.  **Teacher and students**  Discuss changes to energy sources and how that has created a shift in employment opportunities. | Students can describe the sustainable transport hierarchy.  Students can explain some of the impacts changes to energy sources and technology have had on the transport industry. | (Add adjustments and registration) |
| **Battery electric vehicle (BEV)**  **ST5-5**  Students:   * describe innovations used in transport. | **Teacher**  Outline current industry initiatives to move from combustion engines to electric vehicles, for example:   * BEV * hybrid electric vehicle (HEV) * plug-in hybrid electric vehicle (PHEV) * fuel cell electric vehicle (FCEV).   **Students**  Complete a know, want, learn, how chart ([KWLH chart](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/562#.ZCoM53pRppg.link)) about current innovations in electric vehicles.  **Teacher**  Present [B for BEV, Battery Electric Vehicle (7:56)](https://www.youtube.com/watch?v=A9xXcJKC65E).  **Students**  Update KWLH chart with new information presented.  Research the different forms of electric and hybrid vehicles currently on the market and collect data on characteristics like cost, range in kilometres and recharging. Consider characteristics that distinguish electric from combustion vehicles. | Students can describe some recent innovations used in transport.  Students can identify the main differences between electric, hybrid and combustion vehicles. | Use closed captions when viewing videos. |
| **Motors**  **ST5-1**  Students:   * investigate the operation and application of electric motors used in sustainable transport systems * explain the operation of motor technologies used in sustainable transport vehicles. | **Teacher**  Provide models of simple motors and generators for students to examine.  Explain how motors convert electrical energy into kinetic energy.  Present:   * [How do electric vehicles work? (5:06)](https://www.youtube.com/watch?v=GHGXy_sjbgQ) * [Types of motors used in EV (15:52)](https://www.youtube.com/watch?v=6H5vtu5_SF4).   **Students**  Identify the main components in the models (coil, commutator, brushes and magnets). | Students can explain how an electric motor works.  Students can describe the conversion of electrical energy to kinetic energy in electric motors.  Students can describe the different ways BEV and combustion cars gain motion. | Provide students with different options or negotiate the requirements of the task. |
| **Weekly reflection** | **Teacher**  Explain the purpose of a weekly reflection.  Demonstrate how to complete a weekly reflection using a procedural recount text type.  **Students**  Assess what they have learnt, what it means, and how they learn. | Students answer reflective questions, for example:   * When was I at my best this week, and why? * Did I learn best when researching, 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 – materials in BEVs**  **ST5-5**  Students:   * investigate and evaluate materials used in batteries for electric vehicles * develop an understanding of the current and emerging challenges faced by the sustainable transport industry. | **Teacher**  Outline the main materials used in BEV batteries, for example:   * lithium * manganese * cobalt * graphite * steel * nickel.   Briefly explain the use of each material.  **Students**  Research each type of material, considering:   * use * cost * geographic location.   Label world map where the different materials can be found.  Evaluate availability of key battery materials.  Predict issues that could occur with availability of these materials. | Students can describe the materials used in BEVs and where they are found. | (Add adjustments and registration) |
| **Supply chain problems**  **ST5-5**  Students:   * investigate and evaluate materials used in batteries for electric vehicles * develop an understanding of the current and emerging challenges faced by the sustainable transport industry. | **Teacher**  Present the first section of [Why the EV industry has a massive supply problem (53:03)](https://www.youtube.com/watch?v=CM1fL5D1_W8) and describe the BEV supply chain.  Explain how the waste hierarchy relates to BEV batteries.  **Students**  Continue to evaluate the positive and negatives of each material including half-life and volatility.  Investigate the current initiatives that exist to recycle batteries.  Complete a PMI chart on current recycling of battery materials. | Students can describe the materials used in batteries.  Students can explain the challenges the transport industry is facing regarding creation of batteries. |  |
| **Ethics**  **ST5-5**  Students:   * investigate and evaluate materials used in batteries for electric vehicles * develop an understanding of the current and emerging challenges faced by the sustainable transport industry. | **Teacher note -** Please refer to the NSW Department of Education [Controversial Issues in Schools Policy](https://policies.education.nsw.gov.au/policy-library/policies/controversial-issues-in-schools) and support documentation when addressing issues that may be deemed controversial in your local context. An alternative discussion on waste generated by producing batteries and disposing of used batteries may be used as an alternative example for this activity.  **Teacher**  Outline the legal, ethical, and moral responsibilities of vehicle manufacturers regarding the mining of rare materials, for example:   * environmental factors * worker health and safety * protection of cultural sites.   **Teacher and students**  Discuss issues of worker safety and fair trade raised in the article: [Exposed: Child labour behind smart phone and electric car batteries](https://www.amnesty.org/en/latest/news/2016/01/child-labour-behind-smart-phone-and-electric-car-batteries/).  **Students**  Create a text informed by facts and figures highlighting the legal, ethical, or moral responsibilities of vehicle manufacturers. | Students can describe impacts of mining operations on various stakeholders.  Students understand ethical and moral challenges faced by the sustainable transport industry. | Poster can be in physical or digital format. |
| **Weekly reflection** | **Students**  Complete weekly reflections. | Students answer reflective questions, for example:   * Did I face any challenges within the activities, and how did I overcome them? * Which activity did I enjoy the most and why? * How well did I collaborate with other members of my group and how could I improve? | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 3 and 4

Table 2 – sustainable transport weeks 3 and 4 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 3 – Life Cycle Assessment (LCA)**  **ST5-5**  Students:   * compare waste and emissions for a range of powered vehicles * explain the challenges around the implementation of emerging sustainable transport technologies * investigate the Life Cycle Assessment (LCA) of different sustainable transport modes. | **Teacher**  Define [The principles of Life Cycle Assessment (2:55)](https://www.youtube.com/watch?v=r0ucT1KRiO4) as a method of assessing the environmental effects of goods and services.  Explain how LCA can be used to make judgements about the environmental influence of various forms of transportation using [life cycle analysis comparison (12:49)](https://www.youtube.com/watch?v=wurQQPXDNBQ).  **Teacher and students**  Brainstorm a range of factors that hinder the implementation of sustainable transportation, for example:   * existing infrastructure * energy efficiency * manufacturing costs * population growth.   Debate the effects of sustainable transportation on the environment and economy.  Assess costs of switching to various methods of sustainable transportation, for example:   * [electric cars are better for the environment](https://cosmosmagazine.com/technology/yes-electric-cars-are-better-for-the-environment/) * [using public transport to protect the planet (2:44)](https://www.abc.net.au/education/fight-for-planet-a-ch-5-using-public-transport-to-protect-the-pl/13500096)**.** | Students can justify economic costs against the impacts of switching to sustainable forms of transportation. | (Add adjustments and registration) |
| **Pollution and BEVs**  **ST5-5**  Students:   * compare waste and emissions for a range of powered vehicles * explain the challenges around the implementation of emerging sustainable transport technologies * investigate the Life Cycle Assessment (LCA) of different sustainable transport modes. | **Teacher**  Outline how environmentally aware production supports producer responsibility policies for end-of-life vehicles.  Explain how the European Union introducing the[End-of-Life Vehicle directive](https://environment.ec.europa.eu/topics/waste-and-recycling/end-life-vehicles_en) will achieve increasing the use of non-toxic recyclable materials.  **Students**  Access [EV or gas, what pollutes more? (13:53).](https://www.youtube.com/watch?v=1oVrIHcdxjA)  Create a list of 5 advantages and 5 disadvantages of switching to BEVs. | Students can identify a range of positive and negative issues related to sustainable transportation. | (Add adjustments and registration) |
| **Cost analysis**  **ST5-2, ST5-9**  Students:   * apply fundamental mathematical methods to solve transport related problems. | **Teacher**  Explain how cost analysis can be used to justify the choice of vehicle.  Demonstrate how to find the upfront and running costs of different types of electric and combustion engine cars, for example:   * mid-size * Sports utility vehicle (SUV).   Present [how much does it cost to run an electric car?](https://www.budgetdirect.com.au/car-insurance/guides/car-buying/how-much-does-it-cost-to-run-an-electric-car.html)  **Students**  Research running costs of different type of cars.  Use spreadsheets to create stacked bar charts to show the overall cost of each type of vehicle for the first year.  Use spreadsheets to graph the ongoing costs of each type of vehicle to see how long it takes for the electric vehicle to become more cost efficient. | Students will be able to determine the overall costs of different vehicle types and estimate the time it takes for electric vehicles to be comparable or more cost-effective than combustion engine vehicles.  Students can explain different benefits, limitations, risks, and costs associated with some systems. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflections. | Students answer reflective questions, for example:   * What did I learn about this week? * Are BEVs more environmentally friendly than combustion engines? | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 4 – AC/DC charging**  **ST5-2, ST5-4**  Students:   * explain the challenges around the implementation of emerging sustainable transport technologies * describe innovations used in transport * develop an understanding of the current and emerging challenges faced by the sustainable transport industry. | **Teacher**  Explain how BEVs use direct current (DC) and energy from the power grid is alternating current (AC).  Outline the need to convert AC energy from the grid to DC when charging a BEV, which results in energy loss.  Outline the different types of [charging stations](https://www.transport.nsw.gov.au/projects/electric-vehicles/charging-an-electric-vehicle) that currently exist, for example:   * level 1 AC single-phase trickle charger * level 2 AC slow, single-phase charger * level 2 AC fast, three-phase charger * level 3 DC fast charger * level 4 DC super-fast charger.   **Teacher and students**  Investigate the different types of plugs and which types of cars and chargers they are compatible with, for example:   * type 1 (J1772) * type 2 (Mennekes) * combined charging system (CCS) * charge de move (CHAdeMO) * Tesla.   Discuss the disadvantages of multiple types of chargers and investigate how some countries/companies are trying to compensate.  **Extension (Optional)**  Use the worldwide disparity in wall [plugs, sockets and voltage](https://www.worldstandards.eu/electricity/plug-voltage-by-country/) to show students how this could be avoided by early adoption of worldwide standards.  Compare with EU mandate for consistent phone charging plugs. | Students can describe types of charging stations.  Students can outline the type of electricity used in BEVs and BEV chargers.  Students understand the need for cross country and company co-operation in the standardisation of charging stations and plugs. | (Add adjustments and registration) |
| **Charging time**  **ST5-2, ST5-4**  Students:   * collect and manage data from transport related scenarios * describe innovations used in transport. | **Teacher**  Review the different levels of charging stations.  Provide initial sources of BEV car statistics or websites, for example [range and charging](https://www.transport.nsw.gov.au/projects/electric-vehicles/charging-an-electric-vehicle/range-and-charging).  **Students**  Choose 2 or more BEVs from different brands and compare their charging times (using various levels) with their distance range.  **Teacher and students**  Discuss the advantages and disadvantages of each chosen BEV, for example:   * range * fastest charge * aesthetics * special features.   Vote for the best and most efficient BEV, for example:   * sticky dot vote * digital poll. | Students can describe the charging capabilities of a variety of BEVs.  Students can provide reasoned value judgements on a range of BEV related criteria. | (Add adjustments and registration) |
| **Taking a trip**  **ST5-2, ST5-4**  Students:   * explain the challenges around the implementation of emerging sustainable transport technologies * collect and manage data from transport related scenarios * describe innovations used in transport. | **Teacher**  Present a challenge to plan a trip from Coffs Harbour to Sydney comparing 2 different BEVs to complete the trip and incorporate existing BEV charging stations.  **Students**  Investigate the time it takes to charge different BEVs to different levels.  Choose 2 or more BEVs and consider the following questions:   * Is it more efficient to charge cars to 80% between stops? * How long would a journey from Coffs Harbour to Sydney take? * How often would you need to recharge?   Create a diagram showing distances between charges, expected charging times, total distance travelled, and total time taken to reach the finish. | Students understand charging restraints and can plan an efficient journey for a BEV.  Students show through calculations that it is more efficient to make more frequent stops when driving a BEV. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflections. | Students answer reflective questions, for example:   * Are BEVs really cheaper to run than combustion engines? * Why is it important to have consistency across car brands for charger plugs? * 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 5 and 6

Table 3 – sustainable transport weeks 5 and 6 learning sequence

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Week 5 – S-curve**  **ST5-2, ST5-5**  Students:   * define sustainable transport and critically evaluate the impact of sustainable transportation on society and the environment * explore current energy sources used in sustainable transport systems and determine their relative position on the technology s-curve. | **Teacher**  Outline energy sources that can be used to generate electricity and power vehicles as either renewable or non-renewable.  Explain how the adoption (and improvement) of technologies follow a trend-like pattern called the S-curve.  **Teacher and students**  Discuss the advantages and disadvantages of different energy sources used in the production of electricity.  Explore where various renewable energies and associated technologies exist on their S-curves.  **Students**  Investigate how some of the shortfalls of renewable energy are being rectified, for example:   * using battery technology to store solar generated electricity as demonstrated by [Hornsdale Power Reserve](https://hornsdalepowerreserve.com.au/) * hydrogen requires electrolysis to be separated; using renewable energy makes this process zero emission. Watch [the truth about hydrogen (12:07)](https://www.youtube.com/watch?v=AGTjKJHu99c). | Students can identify and describe different renewable electricity systems.  Students can evaluate renewable electricity systems in relation to a given environment or context. | (Add adjustments and registration) |
| **Careers**  **ST5-2, ST5-10**  Students:   * explore a range of Australian and international initiatives designed to reduce environmental impact of transport * investigate the nature of work and pathways into industries that support sustainability and transport related careers * explain the effects of emerging sustainable transport technologies on current and future careers. | **Teacher**  Introduce careers that involve engineering, renewable energy, and transportation, for example:   * [Day at work (3:07)](https://www.youtube.com/watch?v=4oGo8P8CtJw) – solar design engineer video * [renewable energy engineering](https://careerswithstem.com.au/renewable-energy-engineering-faq/#gsc.tab=0) * [civil engineering - Dr Jake Whitehead](https://careerswithstem.com.au/profiles/transport-engineering-uq/#gsc.tab=0) * industry incursion or excursion.   Link career options and current initiatives aimed at making sustainable transportation more available, for example:   * bicycle friendly cities * bike-sharing and scooter-sharing services * smart cities * BEV charging stations * [hydrogen powered prime movers.](https://arena.gov.au/blog/hydrogen-powered-prime-movers-to-roll-into-townsville/)   **Students**  Research a variety of career opportunities in the sustainable transport industry. | Students can describe career opportunities in the sustainable transport industry.  Students can describe some pathways into industries that support sustainability and transport related careers.  Students are able to explain how emerging sustainable transport technologies are affecting current and future careers. | (Add adjustments and registration) |
| **Impact**  **ST5-2, ST5-10**  Students:   * define sustainable transport and critically evaluate the impact of sustainable transportation on society and the environment. | **Teacher and students**  Discuss current Australian and/or international initiatives designed to reduce environmental impact of transport.  **Students**  Evaluate the impact of sustainable transportation on society and the environment. | Students can explain the impact of sustainable transport initiatives on the environment. | (Add adjustments and registration) |
| **Weekly 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. | Students answer reflective questions, for example:   * What did I learn about renewable energy this week? * Why is it important to understand where renewables are on the technology S-curve? * Are smart cities sustainable cities? | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |
| **Week 6 – autonomous vehicles**  **ST5-2, ST5-5**  Students:   * explore a range of Australian and international initiatives designed to reduce environmental impact of transport * explain the challenges around the implementation of emerging sustainable transport technologies * explore challenges of designing navigation systems in autonomous vehicles. | **Teacher**  Introduce autonomous (self-driving) vehicles. Outline [environmental pros and cons of self-driving cars](https://earth.org/pros-and-cons-of-self-driving-cars/).  Show [why self driving cars have stalled (5:31)](https://www.youtube.com/watch?v=4sCK-a33Nkk).  Describe [the 6 levels of driving autonomy](https://www.synopsys.com/automotive/autonomous-driving-levels.html).  Introduce delivery drones and electric vertical take-off and landing (EVTOL).  Explain the need for level 5 autonomy in these types of systems.  **Teacher and students**  Watch [how Dubai is building roads in the sky (7:02)](https://www.youtube.com/watch?v=hWaA8w4bbQ4).  Discuss challenges faced by automotive companies when [designing autonomous vehicles,](https://www.iiot-world.com/artificial-intelligence-ml/artificial-intelligence/five-challenges-in-designing-a-fully-autonomous-system-for-driverless-cars/) for example:   * road, weather and traffic conditions * accident liability * cybersecurityLiDAR and radar interference * safety and reliability * moral and ethical aspects. | Students can describe how government and private industry need to work together to implement sustainable transport initiatives.  Students can explain challenges faced by companies when designing autonomous vehicles. | (Add adjustments and registration) |
| **Artificial Intelligence (AI) models**  **ST5-1, ST5-3, ST5-4**  Students:   * explain the challenges around the implementation of emerging sustainable transport technologies * explore challenges of designing navigation systems in autonomous vehicles. | **Teacher**  Explain how light detection and ranging (LiDAR) is used by autonomous cars to sense pedestrians, cars, and other objects on the road.  **Students**  Investigate autonomous vehicles, and how AI systems are used.  Using [Google Teachable Machine](https://teachablemachine.withgoogle.com/), create a model that can recognise common driving stimuli, for example:   * traffic lights * stop signs * roundabouts * pedestrians * other vehicles.   Export models and share with the class.  Create a PMI board for each individual, or group, model and have peers add ideas to improve current models. | Students can describe challenges faced by companies when designing autonomous vehicles.  Students create an AI model that can recognise common driving stimuli. | (Add adjustments and registration) |
| **Weekly 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. | Students answer reflective questions, for example:   * Why is it important to have level 5 autonomy in vehicles? | Procedural recounts can be prepared on paper or digitally, including speech-to-text or voice recording. |

### Weeks 7–10

Table 4 – sustainable transport weeks 7–10 learning sequence

**Note:** The engineering design process guides the suggested sequence of activities for the next 4 weeks. However, the duration of activities will be directed by teacher professional judgement based on individual student needs. While an example weekly reflection is listed at the end of this 4 week block it should still occur weekly.

|  |  |  |  |
| --- | --- | --- | --- |
| Outcomes and content | Teaching and learning | Evidence of learning | Adjustments and registration |
| **Define and identify**  **ST5-1, ST5-4, ST5-7**  Students:   * explain the sustainability hierarchy associated with regards to transportation and emissions * use project management and communication techniques to plan and document solutions to sustainable transport projects * work individually and collaboratively to apply an engineering design process to complete problems and challenges to sustainable transport scenarios. | **Teacher**  Present a design challenge to create an innovative parking system that will provide commuters easy access to public transport and help reach sustainable transport goals.  Explain that students will present ideas and prototypes to a panel of industry professionals and/or school staff.  Assign students to appropriate groups.  **Students**  Complete a mind map of initial thoughts and questions regarding the design parameters.  Consider the following questions:   * Why do we need better parking solutions? * How does it relate to sustainability? * What makes a good carpark? * What features would make it stand out from existing parking structures? * How can renewable energy be utilised in the design?   Write a clear and concise design brief statement that articulates the scope and nature of the problem.  Create a timeline for completion. | Students have defined the problem and can describe the constraints of the project.  Students create a timeline for their project's creation.  Students have documented their design process. | (Add adjustments and registration) |
| **Brainstorm**  **ST5-1, ST5-3, ST5-4, ST5-7**  Students:   * explore a range of Australian and international initiatives designed to reduce environmental impact of transport * use project management and communication techniques to plan and document solutions to sustainable transport projects * work individually and collaboratively to apply an engineering design process to complete problems and challenges to sustainable transport scenarios. | **Teacher**  Explain that the process of developing designs will increase our knowledge of sustainable transport.  **Students**  Utilise think-pair-share to ideate ideas.  Produce annotated sketches.  Work collaboratively in teams to develop ideas and decide on required materials.  Use [The future of urban mobility (4:04)](https://www.youtube.com/watch?v=_HnLhmXSpUs) to investigate sustainable transport initiatives to help generate ideas that could be incorporated into their parking system, for example:   * [sustainable mobility (6:52)](https://www.youtube.com/watch?v=8Fj2ARn1WMY) * solar street lighting * bicycle lanes * solar roads * [traffic lighting](https://news.mit.edu/2015/smarter-stoplights-cut-greenhouse-gas-0331) * drone [delivery](https://www.mdpi.com/2504-446X/7/2/77) logistics * [shared mobility.](https://sharedusemobilitycenter.org/what-is-shared-mobility/) | Students produce design sketches for their innovative parking system.  Students have documented their design process.  Students produce designs that clearly demonstrate ideas.  Students can describe some sustainable transport initiatives. | Revise brainstorming techniques introduced in [STEM Fundamentals](https://education.nsw.gov.au/teaching-and-learning/curriculum/department-approved-courses/istem#/asset4).  Provide sample sites for students to explore.  Consider accessibility needs and alternative options when producing sketches.  Provide students with different design challenge options and/or negotiate the requirements of the task with appropriate adjustments.  Advanced students could be encouraged to research advanced techniques and seek out additional tutorials.  Work in teams or individually to complete design challenge. |
| **Design**  **ST5-1, ST5-2, ST5-3, ST5-4**  Students:   * apply basic principles occurring in the operation of electrical components and circuits * utilise technologies to produce sustainable transport models or prototypes * design and build a system to solve a sustainable transport problem * work individually and collaboratively to apply an engineering design process to complete problems and challenges to sustainable transport scenarios. | **Teacher and students**  Discuss the ways renewable energy is used in transportation and how students could use it in their parking systems.  **Teacher**  Explain the need for circuits to create an operational final design.  Outline the basic components of a circuit that may be needed to complete the design.  **Students**  Continue to investigate sustainable transport initiatives and begin to design innovative parking system.  Access:   * [How to make a automatic car parking system (8:43)](https://www.youtube.com/watch?v=vZ08Y5aqdpM) * [Arduino automated car parking system (6:29)](https://www.instructables.com/Arduino-Automated-Car-Parking-System/)   Produce several thumbnail sketches and annotated drawings of the initial ideas that include required components.  **Teacher**  Monitor individual and group progress during the designing phase and facilitate group discussion if needed. | Students can show how their ideas can incorporate renewable energy.  Students have documented their design process.  Students produce designs that clearly demonstrate ideas. | Consider accessibility needs and alternative options when producing thumbnail sketches and annotated drawings. |
| **Prototype**  **ST5-1, ST5-2, ST5-3, ST5-4**  Students:   * develop practical skills using appropriate tools to produce transport related solutions, models, prototypes, or experiments * utilise technologies to produce sustainable transport models or prototypes * design and build a system to solve a sustainable transport problem * work individually and collaboratively to apply an engineering design process to complete problems and challenges to sustainable transport scenarios. | **Teacher**  Facilitate design and construction of circuits.  Introduce microcontrollers, sensors, and components that could be used by the class.  Demonstrate applications of sensor, motor, and lights (and/or provide video links) for the system you will be using, for example:   * stepper motors to move boom gate to allow entry of car into parking station * [infrared (IR) sensors](https://www.electronicshub.org/interfacing-ir-sensor-with-raspberry-pi) to detect the presence of a car * [light emitting diodes (LEDs)](https://thepihut.com/blogs/raspberry-pi-tutorials/27968772-turning-on-an-led-with-your-raspberry-pis-gpio-pins) to indicate free spaces.   Organise and facilitate safe fabrication processes, which may include:   * cardboard prototyping * 3D printing * laser cutting.   **Students**  Use designs to begin rapid prototyping.  Complete circuits and code for prototype.  Evaluate and refine prototypes, considering options for:   * BEV charging * space booking * traffic flow * entry points * pedestrian walkways * licence plate recognition sensors.   Evaluate and modify as necessary.  Discuss with other groups and suggest improvements to designs. | Students create working circuit for prototype.  Students create 3D design on CAD software.  Students can create a scaled model using CAD software.  Students demonstrate practical skills using appropriate tools to produce high quality models.  Students use an elevator pitch style presentation to gather ideas for iteration of their designs from other members of class. | (Add adjustments and registration) |
| **Evaluate and iterate**  **ST5-1, ST5-2, ST5-3, ST5-4, ST5-8**  Students:   * develop practical skills using appropriate tools to produce transport related solutions, models, prototypes, or experiments * utilise technologies to produce sustainable transport models or prototypes * use project management and communication techniques to plan and document solutions to sustainable transport projects * design and build a system to solve a sustainable transport problem * work individually and collaboratively to apply an engineering design process to complete problems and challenges to sustainable transport scenarios. | **Teacher**  Review the role of iteration in the engineering design process.  Review and iterate engineering design process questions with students, for example:   * How can the solution be further improved? * How could the solution be more sustainable? * If you decide to make revisions, what will it look like?   **Students**  Complete a critical evaluation of their prototype.  Use critical evaluation to make modifications of sustainable parking system.  Use updated design drawings, materials and equipment to modify their final prototype.  Document their progress for their engineering reports.  Complete a final model to be used in their presentation. | Students document evaluation on how successfully their solution satisfies the requirements of the design challenge.  Students demonstrate capacity to use evaluation to inform adaptation and iteration of their design. | Model an evaluation of a design and remind students of the evaluation process from [STEM fundamentals](https://education.nsw.gov.au/teaching-and-learning/curriculum/department-approved-courses/istem#/asset4) and provide evaluation prompts, for example:   * What revisions or improvements can be made to the design? |
| **Communicate**  **ST5-8, ST5-10**  Students demonstrate innovation and entrepreneurial activity and communicate solutions. | **Teacher**  Review requirements of presentation to panel, emphasising the need to provide a visual context for the project.  Describe features that are required in the presentation, for example:   * defined problem * solution * technology needed * diagrams/charts/images * impact on society and environment.   **Students**  Create a presentation for their innovative parking design.  Predict questions that may be asked by panel members.  **Teacher**  Suggest possible questions that panel members may ask each group, for example:   * Are there similar parking systems already being made? * Given adequate start-up capital, how long would it take to have this parking system up and running? * What technology is needed? And does it already exist? * What was the most difficult part of the project and how did you overcome it? * How well did your team work as a group? | Students create presentation for their parking system which clearly demonstrates critical and creative thinking to develop an innovative parking system solution.  Students demonstrate deep understanding of how parking systems are a way of achieving sustainable transport goals. | (Add adjustments and registration) |
| **Panel**  **ST5-4, ST5-8, ST5-10**  Students:   * engage in industry career development opportunities to gain a deeper knowledge of sustainability and transport related professions, develop skills, knowledge and understanding of authentic, real-world problem-solving * demonstrate innovation and entrepreneurial activity and communicate solutions. | **Teacher**  Organise a panel made of industry representatives and/or school staff.  **Students**  Present prototype and presentation to a panel of industry professionals and school staff. | Students demonstrate entrepreneurship.  Students demonstrate deep knowledge of the Australian and international transport and sustainability industries. | (Add adjustments and registration) |
| **Weekly reflection** | **Students**  Complete weekly reflections. | Students answer reflective questions, for example:   * What did I learn about transport initiatives? * Did I face problems, 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? * What did I learn about the engineering process? * What skills did I apply during this week, and how are those skills important to my possible future career? * 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. |

## Additional information

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

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

### Assessment for learning

Possible formative assessment strategies that could be included:

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

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

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

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

### Differentiation

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

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

* **Aboriginal and Torres Strait Islander students**. Targeted [strategies](https://education.nsw.gov.au/teaching-and-learning/aec/aboriginal-education-in-nsw-public-schools) can be used to achieve outcomes for Aboriginal students in K-12 and increase knowledge and understanding of Aboriginal histories and cultures. Teachers should utilise students’ Personalised Learning Pathways to support individual student needs and goals.
* **EAL/D learners**. EAL/D learners will require explicit English language support and scaffolding, informed by the [EAL/D enhanced teaching and learning cycle](https://education.nsw.gov.au/teaching-and-learning/curriculum/literacy-and-numeracy/resources-for-schools/eald/enhanced-teaching-and-learning-cycle) and the student’s phase on the [EAL/D Learning Progression](https://education.nsw.gov.au/teaching-and-learning/curriculum/multicultural-education/english-as-an-additional-language-or-dialect/planning-eald-support/english-language-proficiency). In addition, teachers can access information about [supporting EAL/D learners](https://education.nsw.gov.au/teaching-and-learning/curriculum/multicultural-education/english-as-an-additional-language-or-dialect/planning-eald-support/english-language-proficiency) and [literacy and numeracy support specific to EAL/D learners](https://education.nsw.gov.au/teaching-and-learning/curriculum/literacy-and-numeracy/resources-for-schools/eald).
* **Students with additional learning needs**. Learning adjustments enable students with disability and additional learning and support needs to access syllabus outcomes and content on the same basis as their peers. Teachers can use a range of [adjustments](https://education.nsw.gov.au/teaching-and-learning/disability-learning-and-support/personalised-support-for-learning/adjustments-to-teaching-and-learning) to ensure a personalised approach to student learning. In addition, [Curriculum planning for every student](https://education.nsw.gov.au/teaching-and-learning/curriculum/planning-programming-and-assessing-k-12#Curriculum0) 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).
* **High potential and gifted learners**. [Assessing and identifying high potential and gifted learners](https://education.nsw.gov.au/teaching-and-learning/high-potential-and-gifted-education/supporting-educators/assess-and-identify#Assessment1) will help teachers decide which students may benefit from extension and additional challenge. [Effective strategies and contributors to achievement](https://education.nsw.gov.au/teaching-and-learning/high-potential-and-gifted-education/supporting-educators/evaluate) for high potential and gifted learners help teachers to identify and target areas for growth and improvement. In addition, the [Differentiation Adjustment Tool](https://education.nsw.gov.au/teaching-and-learning/high-potential-and-gifted-education/supporting-educators/implement/differentiation-adjustment-strategies) can be used to support the specific learning needs of high potential and gifted students. The [High Potential and Gifted Education Professional Learning and Resource Hub](https://schoolsnsw.sharepoint.com/sites/HPGEHub/SitePages/Home.aspx) supports school leaders and teachers to effectively implement the High Potential and Gifted Education Policy in their unique contexts.

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

### About this resource

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

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

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

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

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

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

**Department approved elective course**: iSTEM

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

**Author**: Curriculum Secondary Learners

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

**Resource**: Teaching resource

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

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

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

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

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

**Creation date**: 15th 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).

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