Scientific Studies

OFFICIAL

2024 Subject Outline | Stage 1

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Introduction

Subject description

Scientific Studies is a 10-credit subject or a 20-credit subject at Stage 1, and a 20-credit subject at Stage 2.

Innovative and critical thinking in the world of science underpins a cohesive understanding of the natural world and the discovery of new ways of doing and thinking. Science is continually refining and expanding our knowledge of the universe and, as this happens, stimulating new questions for future investigation.

Through a focus on science inquiry skills and scientific ways of observing, questioning, and thinking, students in Scientific Studies actively investigate and respond to authentic, engaging, and complex questions, problems, or challenges. They employ interdisciplinary approaches with a focus on science and engineering, supported through the application of technology, design, and mathematical thinking (STEM).

Students apply inquiry-based approaches to design, plan, and undertake investigations on a short term or more extended scale, responding to local or global situations. Both collaboratively and individually, they employ a scientific approach to collecting, representing, and analysing data, using technological tools effectively. After critically evaluating their procedures or models, students communicate scientifically to draw evidence-based conclusions that may lead to further testing, exploring more effective methods or solutions, or new questions.

Investigations that students pursue may align with science and/or engineering challenges that could be supported through connections with practising scientists and engineers, industry, and the wider community. Students are guided to engage in scientific investigations that are relevant and of genuine interest, using either scientific methods or engineering design processes related to scientific outcomes.

The context for developing critical and creative thinking and enhancing science inquiry skills may be drawn from diverse areas including, for example: Earth’s resources and materials development, health, food and nutrition, sports and recreation, the environment, infrastructure, technology, and populations.

As students explore scientific phenomena and develop investigable questions, they understand the fundamental importance of science as a human endeavour and articulate their understanding of the interaction between science and society.

Scientific Studies provides a powerful platform for students to develop their capabilities, in particular to think creatively, work collaboratively, and be innovative.

Capabilities

The capabilities connect student learning within and across subjects in a range of contexts.

The SACE identifies seven capabilities. They are:

* literacy
* numeracy
* information and communication technology (ICT) capability
* critical and creative thinking
* personal and social capability
* ethical understanding
* intercultural understanding.

Literacy

In this subject students extend and apply their literacy capability by, for example:

* interpreting the work of scientists across disciplines, using scientific knowledge
* critically analysing and evaluating primary and secondary data
* extracting scientific information presented in a variety of modes
* using a range of communication formats to express ideas logically and fluently, incorporating the terminology and conventions of science
* synthesising evidence-based arguments
* communicating appropriately for specific purposes and audiences.

Numeracy

In this subject students extend and apply their numeracy capability by, for example:

* solving problems using calculations and critical thinking skills
* selecting appropriate instruments to measure with precision and accuracy
* recording, collating, representing, and analysing primary data
* accessing, analysing, and interpreting secondary data
* identifying and interpreting trends and mathematical relationships
* calculating and predicting values by manipulating data and using appropriate scientific conventions.

Information and communication technology (ICT) capability

In this subject students extend and apply their ICT capability by, for example:

* exploring and evaluating technological tools
* collecting, analysing, and representing data electronically using scientific conventions
* modelling concepts and relationships
* using technologies to create new ways of thinking about science
* communicating scientific ideas, processes, and information
* understanding the impact of technology on the development of science and its application in society
* evaluating the application of technology to advance understanding and investigations in science.

Critical and creative thinking

In this subject students extend and apply critical and creative thinking by, for example:

* analysing and interpreting problems from different perspectives
* deconstructing a problem to determine the most appropriate method for investigation
* constructing, reviewing, and revising hypotheses to design innovative investigations
* interpreting and evaluating data and procedures to develop logical conclusions
* analysing interpretations and claims, for validity and reliability
* devising imaginative solutions and making reasonable predictions
* envisaging consequences and speculating on possible outcomes
* recognising the significance of creative thinking on the development of scientific knowledge and applications.

Personal and social capability

In this subject students extend and apply their personal and social capability by, for example:

* understanding the importance of scientific inquiry on health and well-being, both personally and globally
* making decisions and taking initiative while working independently and collaboratively
* planning effectively, managing time, devising and following procedures effectively, and working safely
* sharing and discussing ideas about scientific issues, developments, and innovations while respecting the perspectives of others
* recognising the role of their own beliefs and attitudes in gauging the impact of science in society
* seeking, valuing, and acting on feedback.

Ethical understanding

In this subject students extend and apply their ethical understanding by, for example:

* ascertaining the impacts of their investigations on organisms and the environment
* making ethical decisions based on an understanding of scientific principles
* obtaining, using data, and reporting the outcomes of investigations accurately and fairly
* acknowledging the need to plan for the future and to protect and sustain the biosphere
* exploring the importance of their responsible participation in social, political, economic, and legal decision-making.

Intercultural understanding

In this subject students extend and apply their intercultural understanding by, for example:

* recognising that science is a global endeavour with significant contributions from diverse cultures
* respecting and engaging with different cultural views and customs and exploring their interaction with scientific research and practices
* being open-minded and receptive to change in the light of scientific thinking based on new evidence
* understanding that the progress of science influences and is influenced by cultural factors.

Aboriginal and Torres Strait Islander knowledge, cultures, and perspectives

In partnership with Aboriginal and Torres Strait Islander communities, and schools and school sectors, the SACE Board of South Australia supports the development of high-quality learning and assessment design that respects the diverse knowledge, cultures, and perspectives of Indigenous Australians.

The SACE Board encourages teachers to include Aboriginal and Torres Strait Islander knowledge and perspectives in the design, delivery, and assessment of teaching and learning programs by:

* providing opportunities in SACE subjects for students to learn about Aboriginal and Torres Strait Islander histories, cultures, and contemporary experiences
* recognising and respecting the significant contribution of Aboriginal and Torres Strait Islander peoples to Australian society
* drawing students’ attention to the value of Aboriginal and Torres Strait Islander knowledge and perspectives from the past and the present
* promoting the use of culturally appropriate protocols when engaging with and learning from Aboriginal and Torres Strait Islander peoples and communities.

Health and safety

The handling of live animals, pathogens, and a range of chemicals and equipment requires appropriate health, safety, and welfare procedures.

It is the responsibility of the school to ensure that duty of care is exercised in relation to the health and safety of all students and that school practices meet the requirements of the *Work Health and Safety Act 2012*, in addition to relevant state, territory, or national health and safety guidelines. Information about these procedures is available from the school sectors.

The following safety practices must be observed in all laboratory work:

* Use equipment only under the direction and supervision of a teacher or other qualified person.
* Follow safety procedures when preparing or manipulating apparatus.
* Use appropriate safety gear when preparing or manipulating apparatus.

Any teaching activities that involve the care and use of, or interaction with, animals must comply with the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes*, 8th edition, in addition to relevant state or territory guidelines.

Keeping live animals in an educational setting requires permission from the relevant Animal Ethics Committee. Permission to dissect animals must be obtained in writing from these committees.

For Department of Education and Child Development schools, information can be obtained from the DECD Intranet Animal Ethics webpage (https://myintranet.learnlink.sa.edu.au/educating/extra-curricular-activities/animal-ethics).

The Non Government Schools Animal Ethics Committee is a collaboration between Catholic Education South Australia and the Association of Independent Schools of South Australia (www.ais.sa.edu.au/home/general-information/animal-ethics).

Learning scope and requirements

Learning requirements

The learning requirements summarise the knowledge, skills, and understanding that students are expected to develop and demonstrate through their learning in Stage 1 Scientific Studies.

In this subject, students are expected to:

1. develop and apply science inquiry skills and understanding of scientific concepts, in new and familiar contexts

2. deconstruct a problem, and design and conduct scientific investigations to obtain evidence, using appropriate procedures and safe, ethical working practices

3. evaluate procedures and results, represent and analyse evidence, and formulate and justify conclusions

4. evaluate the effectiveness of collaboration and its impact on results/outcomes

5. explore and understand the interaction between science and society

6. communicate knowledge and understanding of scientific concepts, using appropriate terms, conventions, and representations.

Content

Stage 1 Scientific Studies is a 10-credit subject or a 20-credit subject.

In Stage 1 Scientific Studies, scientific inquiry is the basis for developing integrated programs of learning through which students extend their skills, knowledge, and understanding of the three integrated strands:

* understanding of scientific concepts
* science as a human endeavour
* science inquiry skills.

Science inquiry skills are the focus of learning in this subject. The contexts that students use to explore and inquire into aspects of science should be chosen to suit their particular interests. These contexts should form a framework that enables students to actively engage in inquiry-based learning and further develop their understanding of scientific concepts.

The integration of the three strands within appropriate scientific contexts is symbolised in the diagram below.

large circle diagram labelled science contexts with 3 inner circles overlapping each other, labelled as science inquiry skills, understanding of scientific concepts and science as as a human endevour

When undertaking their investigations, both individually and collaboratively, students innovatively apply scientific methods and/or engineering design processes to promote their problem-solving and analytical skills. By critically analysing the outcomes of their investigations and evaluating the procedures they have used and the effectiveness of collaboration, students enhance their ability to make evidence-based decisions.

Students study a selection of science inquiry skills from the set of skills described in the pages that follow as well as a selection of scientific concepts relevant to the disciplines and/or contexts. They should study these concepts in sufficient depth to then be able to design and undertake investigations. One or more contexts may be used as the framework for studying these inquiry skills.

Together with science as a human endeavour, the science inquiry skills and understanding of scientific concepts form the basis of teaching, learning, and assessment in this subject.

three cog wheels  symbol Understanding of Scientific Concepts

Students develop and extend their knowledge and understanding of key scientific concepts through the contexts they are investigating. These key scientific concepts may include, for example: organisation and patterns, systems, cause and effect, structure and function, scale and measurement, change, energy and matter, and diversity. Contemporary scientific concepts such as contingent superorganisms, cycles, deep time, holism, powers of 10, sceptical empiricism, and randomness may also be explored. Students may explore and extend their understanding of a range of scientific concepts relevant to the contexts they are studying, and investigate and apply their understanding of these concepts through the science inquiry skills. Students make connections between these key scientific concepts and their influence in society through investigations of science as a human endeavour.

The contexts provide the framework discipline for developing, understanding, and investigating the key scientific concepts. These contexts may relate to a single science discipline (for example, human biology or organic chemistry). Alternatively, the contexts may encompass two or more science disciplines, or may draw more heavily across the range of technology, engineering, and mathematics with key scientific concepts as the underlying focus.

Key scientific concepts that are relevant to the contexts into which the students are inquiring are explored to facilitate and support their investigations.

For a 10-credit subject, it is recommended that approximately 15–20 hours of class time relates to the understanding of scientific concepts.

For a 20-credit subject, it is recommended that approximately 35–40 hours of class time relates to the understanding of scientific concepts.

In conjunction with both their investigations and the development of their understanding of key scientific concepts, students extend their understanding of the role that scientific investigation has in society as they explore the key concepts of science as a human endeavour described in the subject outline.

human body symbol Science as a Human Endeavour

The science as a human endeavourstrand highlights the development of science as a way of knowing and doing, and explores the use and influence of science in society.

By exploring science as a human endeavour, students develop and apply their understanding of the complex ways in which science interacts with society, and investigate the dynamic nature of science. They explore how scientists develop new understanding and insights, and produce innovative solutions to everyday and complex problems and challenges in local, national, and global contexts. In this way, students are encouraged to think scientifically and make connections between the work of others and their own learning. This enables them to explore their own solutions to current and future problems and challenges.

Students understand that the development of scientific concepts, models, and theories is a dynamic process that involves analysis and interpretation of evidence and sometimes produces ambiguity and uncertainty. They consider how and why scientific concepts, models, and theories are continually reviewed and reassessed as new evidence is obtained and emerging technologies enable new avenues of investigation. They understand that scientific advancement involves a diverse range of individual scientists and teams of scientists working within an increasingly global community of practice.

Students explore how scientific progress and discoveries are influenced and shaped by a wide range of social, economic, ethical, and cultural factors. They investigate, individually and collaboratively, ways in which the application of science may provide great benefits to individuals, the community, and the environment, but may also pose risks and have unexpected outcomes. They understand how decision-making about socio-scientific issues often involves consideration of multiple lines of evidence and a range of needs and values. As critical thinkers, they appreciate science as an ever-evolving body of knowledge that frequently informs public debate, but is not always able to provide definitive answers.

The key concepts of science as a human endeavour underpin the contexts, approaches, and activities in this subject, and must be integrated into all teaching and learning programs.

The key concepts of science as a human endeavour, with elaborations that are neither comprehensive nor exclusive, in the study of Scientific Studies are:

Communication and Collaboration

* Science is a global enterprise that relies on clear communication, international conventions, and review and verification of results.
* Collaboration between scientists, governments, and other agencies is often required in scientific research and enterprise.

Development

* Development of complex scientific models and/or theories often requires a wide range of evidence from many sources and across disciplines.
* New technologies improve the efficiency of scientific procedures, practices, and data collection and analysis. This can reveal new evidence that may modify or replace models, theories, and processes.

Influence

* Advances in scientific understanding in one field can influence and be influenced by other areas of science, technology, engineering, and mathematics.
* The acceptance and use of scientific knowledge can be influenced by social, economic, cultural, and ethical considerations.

Application and Limitation

* Scientific knowledge, understanding, and inquiry can enable scientists to develop solutions, make discoveries, design action for sustainability, evaluate economic, social, cultural, and environmental impacts, offer valid explanations, and make reliable predictions.
* The use of scientific knowledge may have beneficial or unexpected consequences; this requires monitoring, assessment, and evaluation of risk, and provides opportunities for innovation.
* Science informs public debate and is in turn influenced by public debate; at times, there may be complex, unanticipated variables or insufficient data that may limit possible conclusions.

### question mark symbol Science Inquiry Skills

In Scientific Studies, investigation is an integral part of the learning and understanding of concepts, using scientific methods and/or engineering design processes to test ideas and develop new knowledge, with the possible inclusion of scientific methods used by other cultures.

The following is a summary of the key stages of scientific methods and engineering design processes that are fundamental to investigations.

|  |  |  |
| --- | --- | --- |
|  | Scientific methods | Engineering design processes |
| Observe Question Propose | Identify a question | Notice a problem, need, or opportunity |
| Undertake background research | |
| Formulate a hypothesis | Propose a solution |
| Plan Design Collate Analyse | State a hypothesis and identify variables | State a proposed solution and specify requirements |
| Design an investigation procedure to test a hypothesis | Design a model or prototypeto test a solution |
| Conduct trials, obtain and represent data | |
| Analyse/interpret data and formulate conclusions | |
| Reflect Evaluate Conclude Communicate | Evaluate procedures | Evaluate models or prototypes |
| Modification and iterative testing may occur at this stage | |
| Make and justify conclusions | |
| Communicate results and findings | Communicate outcomes and findings |

Practical investigations must involve a range of both individual and collaborative activities, during which students extend the science inquiry skills described in the subject outline.

Practical activities may take a range of forms, such as using or developing models and simulations that enable students to develop a better understanding of particular concepts related to science inquiry skills. The activities include laboratory and field studies during which students develop investigable questions and/or notice a problem or need, formulate a testable hypothesis or propose a solution, and select and use equipment appropriately to collect data. The data may be observations, measurements, or other information obtained during the investigation.

Students represent and analyse the data they have collected, evaluate procedures, models and/or prototypes, describe the limitations of the data and procedures, and consider explanations for their observations. They may then refine their procedures or proposed solution and undertake further testing. They present and justify conclusions appropriate to the initial question or hypothesis.

Science inquiry skills are fundamental to students investigating the social, ethical, and environmental impacts and influences of the development of scientific understanding and the applications, possibilities, and limitations of science. These skills enable students to critically analyse and interpret the evidence they obtain so that they can present and justify conclusions.

Students study a selection of science inquiry skills from the set of skills described in the pages that follow, as well as a selection of scientific concepts relevant to the disciplines and/or contexts.

The descriptions of the science inquiry skills are structured in two columns: the left-hand column sets out the science inquiry skills and the right-hand column sets out possible contexts through which students may extend their understanding and apply these skills.

The possible contexts are suggestions for potential approaches, and are neither comprehensive nor exclusive. Teachers may select from these and are encouraged to consider other approaches according to local needs and interests.

For a 10-credit subject, it is recommended that a minimum of 25–30 hours of class time involves practical activities.

For a 20-credit subject, it is recommended that a minimum of 50–60 hours of class time involves practical activities.

Within the descriptions of the science inquiry skills, the following symbols are used in the possible contexts to show how a strand of science can be integrated:

|  |  |
| --- | --- |
| three wheels cog symbol | indicates a possible teaching and learning strategy for understanding a science inquiry skill |
| question mark symbol | indicates a possible science inquiry activity |
| human body symbol | indicates a possible focus on science as a human endeavour. |

| Science Inquiry Skills | Possible contexts |  |
| --- | --- | --- |
| Scientific evidence |  |  |
| Critical thinking allows claims and arguments to be analysed through empirical evidence, authority, logic, and intuition.   * Apply claim testers to analyse the validity of claims. | Discuss claim testers, such as those described in the Big History Project:  <https://school.bighistoryproject.com/media/bhp3video/U1_BobBain_HowDoWeDecide.mp4>  Investigate claims made by advertisers and analyse the available evidence.  Explore different types of scientific evidence identified in Compound Interest:  <http://www.compoundchem.com/2015/04/09/scientific-evidence/> | three cogs symbol |
| Investigate claims made in food advertising and their impact on society.  Discuss false ‘facts’ using:  <http://science.howstuffworks.com/science-vs-myth/everyday-myths/10-false-facts1.htm> | human body symbol |
| Approaches to science and engineering |  |  |
| Progress in science is often advanced through engineered solutions, while technology and engineering develop through creative applications of science.  Many stages are shared in the application of scientific methods and engineering design processes.   * Investigate different scientific methods. * Compare scientific methods to engineering design processes.   Progress in science often requires refinement of procedures and repeated testing. | Discuss the iterative nature of scientific inquiry. | three cogs symbol |
| Construct flow charts to represent processes for scientific methods and engineering design processes. | question mark symbol |
| Investigate examples of progress in science and engineering made through:   * serendipitous discovery   <http://www.popularmechanics.com/science/health/g1216/10-awesome-accidental-discoveries/>   * practical problem solving   <http://www.stonybrook.edu/happenings/facultystaff/solving-global-issues-through-empathetic-technological-design/>   * technological advances and the interaction between science and technology   <http://undsci.berkeley.edu/article/whathassciencedone_03> | human body symbol |
|  | Discuss the importance of international collaboration, e.g. involving the CERN Large Hadron Collider:  <http://indico.cern.ch/event/28617/contributions/1638133/attachments/531112/732392/aaas_feb08.pdf> | human body symbol |
| Observations |  |  |
| Observations lead to the recognition of patterns and trends, the construction of meaning, the development of conclusions, or the development of further questions to investigate.  Observations in science involve using the senses or instruments to acquire primary data.   * Record a range of observations from scientific phenomena. | Undertake simple chemical reactions (such as precipitation) or produce physical changes (e.g. evaporation of salt solution on a microscope slide) to record detailed observations.  View and record observations for a range of physical or chemical changes using:  <http://www.beautyofscience.com/>  Determine the contents of a sealed box. | question mark symbol |
| Questioning and thinking |  |  |
| The interactions between science, technology, and society are driven by the questioning of encountered phenomena and the recognition of needs, challenges, problems, and opportunities that arise.   * Construct investigable questions that can be pursued though scientific methods. * Identify needs, problems, challenges, and opportunities, whereby solutions can be engineered.   Investigations are designed to enable observations to be explored, questions to be answered, and possible solutions to be generated.  Complex problems need to be deconstructed into manageable problem sets. This often requires synthesising new knowledge. | Discuss ways to deconstruct a problem.  Discuss aspects of testing ideas using, for example:  http://undsci.berkeley.edu/article/scienceflowchart | three cogs symbol |
| Formulate questions and identify problems to investigate both individually and collaboratively. These may be developed but not investigated further.  Useful website:  <https://www.exploratorium.edu/explore> | question mark symbol |
| * Deconstruct a problem by: * identifying the factors that impact on a problem * determining how the factors impact on the problem * determining and justifying by research or trialing, the most appropriate materials, method, or model to investigate a possible solution to the problem.   Preliminary research leads to predictions |  |  |
| Design |  |  |
| Identification of the factors that influence an investigation can lead to the development of a hypothesis.   * Formulate a testable hypothesis.   Variables are factors that may affect the outcome of an investigation. They can be altered, measured, and may be controlled in investigations.   * Identify types of variables: * dependent * independent * factors held constant (how and why they are controlled) * factors that may not be able to be controlled (and why not).   Scientifically designed procedures provide measurable evidence.   * Design procedures to investigate observations, questions, and problems. * Design and construct testable models and prototypes.   Materials are required to implement scientific investigations.   * Identify required materials.   Safety and ethics are essential in any scientific investigation.   * Identify safety and ethical considerations.   Investigations often require iterative or non-sequential approaches.   * Recommend and/or undertake subsequent or related investigations. | Identify and discuss relevant ethical and legal considerations in different contexts, using, for example:  http://www.visionlearning.com/en/library/Process-of-Science/49/Scientific-Ethics/161  Use scenarios to explore safety and ethical risks. | three cogs symbol |
| Design investigations that require investigable questions and imaginative solutions (with or without implementation).  Critique proposed investigations, using the conclusion of one investigation to propose subsequent experiments.  Change an independent variable or requirement in a given procedure or design and adapt the method.  Research, develop, and trial methods or designs.  Improve an existing procedure or design.  Identify options for measuring the dependent variable.  Research hazards related to the use and disposal of chemicals and materials, using, for example:  [https://www.safework.sa.gov.au/resources/managing-risks-hazardous-chemicals-workplace#](https://www.safework.sa.gov.au/resources/managing-risks-hazardous-chemicals-workplace%23)  Develop safety audits using the example from the Student RiskAssess brochure:  <https://www.riskassess.com.au/info/learning_resources> | question mark |
| Investigate the impacts of examples of scientific fraud using, for example:  [http://www.the-scientist.com/?articles.view/ articleNo/41718/title/Top-Science-Scandals-of-2014/](http://www.the-scientist.com/?articles.view/%20articleNo/41718/title/Top-Science-Scandals-of-2014/)  <https://explorable.com/science-fraud> | human body |
| Conducting investigations |  |  |
| Obtaining meaningful data depends on conducting investigations using appropriate procedures and safe, ethical working practices.   * Conduct investigations, including: * selection and safe use of appropriate materials, apparatus, and equipment * individual and collaborative work. | Discuss and identify equipment, materials, or instruments fit for purpose. | three cogs symbol |
| Practise techniques and safe use of apparatus, using, for example, Interactive Lab Primer:  [http://www.rsc.org/learn-chemistry/ resource/res00001064/the-interactive-lab-primer?cmpid=CMP00007674](http://www.rsc.org/learn-chemistry/%20resource/res00001064/the-interactive-lab-primer?cmpid=CMP00007674)  Practise small-scale laboratory techniques. | question mark symbol |
| Discuss contributions of scientists who invented significant pieces of apparatus, or techniques (e.g. Robert Bunsen, Heinrich Schnitger, John Severinghaus, or Florence B Seibert) and the impact their inventions have had on society. | human body symbol |
| Collecting data |  |  |
| Observations allow for the collection and recording of data that is both qualitative and quantitative.  Quantitative data can be generated from qualitative data.   * Distinguish between qualitative and quantitative data. * Collect and record examples of qualitative and quantitative data. * Generate quantitative data from appropriate sources of qualitative data.   Primary data is collected directly from investigations, whereas secondary data is obtained indirectly from other sources.   * Record, collate, and analyse primary data. * Access and interpret secondary data. | Investigate how qualitative and quantitative data can be collected, such as measuring plant population density using the quadrat method.  https://www.youtube.com/watch?v=KuG-UjpQzm0  Use smartphones to collect and analyse data, e.g. using:  <http://www.phonelabs.net/>  Compare the accuracy and/or sensitivity of different data-collecting tools or sensors. | question mark symbol |
| Discuss the impact that data collection and reporting has on society. This could include, for example, collection of exercise data, heart rate, or blood sugar level, or the reporting of data related to different types of cancers. | human body symbol |

| Science Inquiry Skills | | Possible contexts | |  |
| --- | --- | --- | --- | --- |
| Representing data |  | | |  |
| Tables, charts, and graphs can be used to represent the results of investigations and support the collation and analysis of data.   * Construct appropriate tables for the collection of data, including headings and units. | Discuss guidelines for making data tables, e.g. using:  <http://www.sedl.org/afterschool/toolkits/science/pdf/ast_sci_data_tables_guidelines.pdf>  <http://www.sedl.org/afterschool/toolkits/science/pdf/ast_sci_data_tables_checklist.pdf> | | | three cogs symbol |
| Tables can be used to organise and process raw data.   * Use tables to organise and process raw data.   Data can be represented visually as charts, graphs, and diagrams, including pie charts, bar graphs, line graphs, and scatter plots.  Visually displaying data can allow for comparisons of the relative size of values and relationships to be established between variables.   * Select the most effective representation of data. * Construct charts and graphs, including appropriate features such as: * axes (variables) * scale and range * labels * units * data points * line of best fit. | | Discuss the advantages and disadvantages of different methods for representing data. | | three cogs symbol |
| Practise constructing data tables, using, for example:  <http://www.sedl.org/afterschool/toolkits/science/pdf/ast_sci_data_tables_sample.pdf>  ‘A Beginner’s Guide to Graphing Data’:  <https://www.youtube.com/watch?v=9BkbYeTC6Mo>  Construct graphs:   * by hand * using software. | | question mark symbol |
| Discuss the misunderstandings that can result when data is presented in a misleading way, e.g. by using an inappropriate scale.  Useful website:  <http://gator.gatewayk12.org/~smcgrail/myweb/powerpoint/misleading_graphs/here_are_some_examples_of_mislea.htm>  Explore claims made using data inappropriately in food advertising. | | human body symbol |
| Variability in data | |  | |  |
| For all measurements, there is uncertainty in the measured values, hence a source of variability in data.  Variability depends both on the nature of the measuring instrument and on what is being measured.   * Analyse sets of data or graphs to determine the degree of scatter. | | Explore examples of variations in data, e.g. using:  <http://www.visionlearning.com/en/library/Process-of-Science/49/Uncertainty-Error-and-Confidence/157>  <https://www2.southeastern.edu/Academics/Faculty/rallain/plab193/labinfo/Error_Analysis/06_Sources_of_Error.html>  <https://www.ma.utexas.edu/users/mks/RA/hiddenuncert.pdf> | | question mark symbol |
| Scatter indicates the presence of random errors.   * Identify sources of random error in an investigation.   The design of an experiment should minimise the effects of random errors.  Describe the effect of increasing the sample size in an investigation.  The accuracy of results is altered by the presence of systematic errors.   * Identify sources of systematic error in an investigation.   Describe the importance of repeating an investigation. | |  | |  |
| Evaluation | |  | |  |
| Critical evaluation of procedures and analysis of data can determine the reliability and accuracy of the data.   * Discuss the impact that sources of uncertainty have on experimental results. | | Discuss how the repeating of an investigation with different materials/equipment may detect a systematic error.  Use an example of an investigation report to develop report-writing skills. | | three cogs symbol |
| Evaluate procedures and data sets provided to determine and hence comment on the limitations of possible conclusions. | | question mark symbol |
| Conclusions | |  | |  |
| Critical evaluation of procedures and data/outcomes can determine the meaningfulness of conclusions.   * Select and use evidence and scientific understanding to make and justify conclusions. * Recognise the limitations of conclusions.   The results of some investigations may not lead to definitive conclusions.  Improvements or changes to the procedure may enable other conclusions to be considered. | | Evaluate procedures and data sets provided by the teacher to determine and hence comment on the limitations of possible conclusions.  Use data sets to discuss the limitations of the data in relation to the range of possible conclusions that could be made.  Discuss ways to further investigate problems or improve experimental methods so that alternative conclusions may be considered. | | three cogs symbol |
| Perform experiments to test an improvement to a procedure to determine if the conclusion can be altered. | | question mark symbol |
| Collaboration | |  | |  |
| Collaboration increases the likelihood of a successful outcome by bringing together diverse ideas, enabling critical discussion and feedback, and sharing expertise.   * Collaborate in various ways to communicate ideas, suggest solutions, and justify and defend decisions. * Work effectively with others, including peers, community members, industry representatives, and/or via online opportunities. * Evaluate the effectiveness of the collaboration undertaken. | | Use the jigsaw technique to help students develop effective communication skills in a group.  Discuss real‑world problems to develop critical and creative thinking skills.  Useful website:  https://research.acer.edu.au/cgi/viewcontent.cgi?article=1043&context=ar\_misc | | question mark symbol |
| Scale drawings and diagrams | |  | |  |
| Scale drawings of objects or observations ensure that all dimensions of the original object are multiplied by a scale factor.   * Draw objects to scale.   Scientific diagrams are constructed by simple line representations and are clearly labelled.   * Draw and label accurate representations of scientific apparatus. | | Construct scale drawings using design or drawing software.  Practise drawing laboratory instruments and apparatus.  <http://www.pearsonplaces.com.au/portals/0/teacherlounge/sf1_2/sf1hw12.pdf>  Develop skills representing scientific images electronically using free software. | | question mark symbol |
| Communicating science | |  | |  |
| Science communication often requires complex concepts and terminology to be simplified into accessible ideas and language.   * Communicate understanding and findings using appropriate scientific language fit for purpose and audience.   Processes and interconnected concepts can be represented as flow charts and concept maps.   * Construct concept maps and flow charts.   Representation of data, trends, outcomes, and concepts is important to convey meaningful findings.   * Represent findings using, for example: infographics, animations, simulations, videos, interviews, presentations, and images.   Scientific findings often undergo peer review and scrutiny to increase credibility.   * Select and acknowledge peer-reviewed sources. * Participate in a peer review of written and/or electronic submissions. | | Discuss ways in which science is communicated to the public, using, for example:  NOVA Science in the News  <http://www.nova.org.au/>  ABC Science Online  <http://www.abc.net.au/science/>  Discuss the importance and limitations of peer review:  <https://sciencebasedmedicine.org/the-importance-and-limitations-of-peer-review/>  Distinguish between reference lists and bibliographies.  Discuss different styles of citation, using, for example:  <http://www.scientificstyleandformat.org/Tools/SSF-Citation-Quick-Guide.html> | | three cogs symbol |
| Review scientific articles or presentations to recognise conventions.  Construct flow diagrams or concept maps by hand or electronically, using concept‑mapping tools, for example:  <https://ltlatnd.wordpress.com/2011/05/11/ten-popular-concept-mapping-tools/> | | question mark symbol |
| The contributions of others are acknowledged through the use of appropriate citations.   * Acknowledge sources through recognised conventions. * Construct bibliographies and reference lists. | | Improve science communication skills using, for example:  UBC Science Writing  <https://www.youtube.com/channel/UCvynvmsn_NTlS9lc8cH-OFw>  <https://youtu.be/y66YKWz_sf0> | question mark symbol | |
| Use written, oral, and multimodal formats to communicate scientifically. Use, for example, presentation software such as:  <https://prezi.com/>  <https://www.powtoon.com/?edgetrackerid=10065846701972&gclid=COqbl-DRus4CFYNjvAodwscKkA>  Analyse referencing and/or footnoting in articles from different sources. | question mark symbol | |
| Investigate examples of peer review having significant impact, e.g. in the use of thalidomide. | human body symbol | |

Assessment scope and requirements

Assessment at Stage 1 is school based.

Evidence of learning

The following assessment types enable students to demonstrate their learning in Stage 1 Scientific Studies:

* Assessment Type 1: Inquiry Folio
* Assessment Type 2: Collaborative Inquiry.

For a 10-credit subject, students should provide evidence of their learning through four assessments. Each assessment type should have a weighting of at least 20%. Students undertake:

* one inquiry folio, comprising:
* two tasks with a focus on science inquiry skills
* one investigation with a focus on science as a human endeavour
* one collaborative inquiry.

For a 20-credit subject, students should provide evidence of their learning through six to eight assessments. Each assessment type should have a weighting of at least 20%. Students undertake:

* one inquiry folio, comprising:
* four tasks with a focus on science inquiry skills
* one longer or two shorter investigations with a focus on science as a human endeavour
* one longer or two shorter collaborative inquiries.

Assessment design criteria

The assessment design criteria are based on the learning requirements and are used by teachers to:

* clarify for the student what he or she needs to learn
* design opportunities for the student to provide evidence of his or her learning at the highest possible level of achievement.

The assessment design criteria consist of specific features that:

* students should demonstrate in their learning
* teachers look for as evidence that students have met the learning requirements.

For this subject the assessment design criteria are:

* investigation, analysis, and evaluation
* knowledge and application.

The specific features of these criteria are described below.

The set of assessments, as a whole, must give students opportunities to demonstrate each of the specific features by the completion of study of the subject.

Investigation, Analysis, and Evaluation

The specific features are as follows:

IAE1 Deconstruction of a problem and design of a scientific investigation, using a scientific method and/or engineering design process.

IAE2 Obtaining, recording, and representation of data, using appropriate procedures, conventions, and formats.

IAE3 Analysis and interpretation of results to formulate and justify conclusions.

IAE4 Evaluation of procedures and their effect on data.

IAE5 Evaluation of the effectiveness of collaboration and its impact on results/outcomes.

Knowledge and Application

The specific features are as follows:

KA1 Demonstration of knowledge and understanding of science inquiry skills and scientific concepts.

KA2 Application of science inquiry skills and scientific concepts in new and familiar contexts.

KA3 Exploration and understanding of the interaction between science and society.

KA4 Communication of knowledge and understanding of scientific concepts, using appropriate terms, conventions, and representations.

School assessment

Assessment Type 1: Inquiry Folio

For a 10-credit subject, students undertake:

* two tasks with a focus on science inquiry skills
* one investigation with a focus on science as a human endeavour.

For a 20-credit subject, students undertake:

* four tasks with a focus on science inquiry skills
* one longer or two shorter investigations with a focus on science as a human endeavour.

Science Inquiry Skills Tasks

Students use science inquiry skills to inquire into aspects of science from various perspectives. These inquiries may involve contexts of interest or contexts based on scientific concepts that enable students to extend their science inquiry skills through practical tasks, and/or selecting, analysing, and interpreting information related to science inquiry skills in various forms.

Science inquiry skills tasks can be conducted individually or collaboratively; however, for each task, students present their own outcomes.

Science inquiry may include engineering design for the purposes of this subject.

Science inquiry skills tasks allow students to provide evidence of their learning in tasks that may:

* be applied, analytical, and/or interpretative
* pose problems in new and familiar contexts.

Science inquiry skills tasks may include, for example:

* design of practical investigations
* completion of practical investigations
* prototype design and testing to find new solutions
* investigation of scientific claims
* analysing the accuracy of published data
* identifying trends and forming hypotheses from ‘big data’ sets
* investigation of the accuracy of equipment or models
* investigation of scientific myths
* research into discipline knowledge
* delivery of workshops
* preparation for and participation in a debate
* a response to science in the media
* developing simulations or models
* practical and/or data representation skills
* analysing the effectiveness of equipment for use.

As a set, science inquiry skills tasks should be designed to enable students to apply their science inquiry skills, demonstrate knowledge and understanding of key scientific concepts and learning, and explain connections with science as a human endeavour. Students should inquire into problems and scenarios in a relevant context.

For a 10-credit subject, the set of science inquiry skills tasks should be a maximum of 6 pages or the equivalent in multimodal form.

For a 20-credit subject, the set of science inquiry skills tasks should be a maximum of 9 pages or the equivalent in multimodal form.

Pages should be single-sided A4 with minimum font size 10. Page reduction, such as two A4 pages reduced to fit on one A4 page, is not acceptable.

Science as a Human Endeavour Investigation

Students investigate a contemporary example of how science interacts with society. This may focus on one or more of the aspects of science as a human endeavour described on pages 9 and 10, and may draw on an inquiry context or a discipline context.

Students could consider, for example, how:

* humans seek to improve their understanding and explanation of the natural world
* working scientifically is a way of obtaining knowledge that allows for testing scientific claims
* scientific theory can change in the light of new evidence
* technological advances change ways of working scientifically
* links between advances in science impact and influence society
* society influences scientific research
* emerging engineering-related careers and pathways involve science.

Students select and explore a recent discovery, innovation, issue, or advance. They analyse and synthesise information from different sources to explain the scientific concepts relevant to the focus of their investigation, show its connections to science as a human endeavour, and develop their own conclusions. The investigation should be related to the program that the students are undertaking.

Possible starting points for the investigation could include, for example:

* the announcement of a discovery in the field of science
* an expert’s point of view on a controversial innovation
* a TED talk based on a scientific development
* an article from a scientific publication (e.g. *Cosmos*)
* public concern about an issue that has environmental, social, economic, or political implications.

Based on their investigation, students prepare a scientific communication, which must include the use of scientific terminology.

For a 10-credit subject, the communication should be a maximum of 6 minutes if oral, 1000 words if written, or the equivalent in multimodal form.

For a 20-credit subject, the communication can be either:

* two tasks that are each a maximum of 6 minutes if oral, 1000 words if written, or the equivalent in multimodal form

or

* one task that is a maximum of 10 minutes if oral, 1500 words if written, or the equivalent in multimodal form.

The communication could take the form of, for example:

* an oral or multimodal scientific presentation
* an article for a scientific publication.

For this assessment type, students provide evidence of their learning primarily in relation to the following assessment design criteria:

* investigation, analysis, and evaluation
* knowledge and application.

Assessment Type 2: Collaborative Inquiry

For a 10-credit subject, students undertake one collaborative inquiry.

For a 20-credit subject, students undertake one longer or two shorter collaborative inquiries.

The collaborative inquiry has two parts:

* the collaborative inquiry design
* the collaborative inquiry evaluation.

Collaborative Inquiry Design

Students collaborate to design and conduct a scientific investigation related to the program and for which the outcome is uncertain. Students are encouraged to experiment with and test ideas using primary data they have obtained. The design may be based on the development of an investigation using a hypothesis or based on the development of an innovative prototype to solve a real-world problem. The design enables students to extend their science inquiry skills by:

* deconstructing a problem to determine the most appropriate method for investigation
* formulating investigable questions, hypotheses, or proposed solutions
* selecting, trialling, and using appropriate equipment, apparatus, and techniques
* identifying variables.

Science inquiry may include engineering design for the purposes of this subject.

Students record individually, in a personal journal:

* initial thinking, ideas, and their individual deconstruction of the problem
* evidence of their own contribution to the project and supporting documentation on the group’s application of collaborative skills
* representation(s) of the data collected by the group
* analysis and interpretation of the results/outcomes
* connections between results and scientific concepts
* an evaluation of the procedures and their effect on data
* a conclusion with justification and the consideration of possible limitations.

For a 10-credit subject, the personal journal should have no more than eight A4 pages if written or the equivalent in multimodal form.

For a 20-credit subject, the personal journal (across the collaborative inquiry or inquiries) should have a total of no more than sixteen A4 pages if written or the equivalent in multimodal form.

Pages should be single-sided A4 with minimum font size 10. Page reduction, such as two A4 pages reduced to fit on one A4 page, is not acceptable.

The personal journal represents the work and critical thinking of the student.

The journal should include the student’s deconstruction and may also include, but is not limited to:

* planning strategies
* methods trialled
* suggestions for improvements
* ideas or questions investigated or posed
* reflection on progress
* pictorial record of experiments
* analysis of primary data
* future planning
* peer review.

Collaborative Inquiry Evaluation

Students individually evaluate the effectiveness of the group’s collaborative skills, when:

* identifying a problem
* deconstructing the problem
* formulating an investigable question, testable hypothesis, or proposed solutions
* identifying variables
* designing appropriate procedures
* collecting data

Evidence is presented in the form of a recorded presentation.

For a 10-credit subject, the evaluation (recorded presentation) should be a maximum of 3 minutes per student if oral or the equivalent if multimodal.

For a 20-credit subject, the evaluation (recorded presentation) should be either a maximum of 3 minutes per student for each of two shorter collaborative inquiries, or a maximum of 5 minutes per student for one longer collaborative inquiry if oral, or the equivalent if multimodal.

The format of the evaluation may be, for example:

* conversation with the teacher and/or other students
* individually recorded
* multimodal.

For this assessment type, students provide evidence of their learning in relation to the following assessment design criteria:

* investigation, analysis, and evaluation
* knowledge and application.

Performance standards

The performance standards describe five levels of achievement, A to E.

Each level of achievement describes the knowledge, skills, and understanding that teachers refer to in deciding how well a student has demonstrated his or her learning on the basis of the evidence provided.

During the teaching and learning program the teacher gives students feedback on their learning, with reference to the performance standards.

At the student’s completion of study of a subject, the teacher makes a decision about the quality of the student’s learning by:

* referring to the performance standards
* taking into account the weighting of each assessment type
* assigning a subject grade between A and E.

Performance Standards for Stage 1 Scientific Studies

| - | Investigation, Analysis, and Evaluation | Knowledge and Application |
| --- | --- | --- |
| A | Critically deconstructs a problem and designs a logical, coherent, and detailed scientific investigation, using a scientific method and/or engineering design process.  Obtains, records, and represents data, using appropriate procedures, conventions, and formats accurately and highly effectively.  Systematically analyses and interprets data and evidence to formulate logical conclusions with detailed justification.  Critically and logically evaluates procedures and their effect on data.  Critically and perceptively evaluates the effectiveness of collaboration and its impact on results/outcomes. | Demonstrates deep and broad knowledge and understanding of a range of science inquiry skills and scientific concepts.  Applies science inquiry skills and scientific concepts highly effectively in new and familiar contexts.  Critically explores and understands in depth the interaction between science and society.  Communicates knowledge and understanding of scientific concepts coherently, with highly effective use of appropriate terms, conventions, and representations. |
| B | Logically deconstructs a problem and designs a well-considered and clear scientific investigation, using a scientific method and/or engineering design process.  Obtains, records, and represents data, using appropriate procedures, conventions, and formats mostly accurately and effectively.  Logically analyses and interprets data and evidence to formulate suitable conclusions with reasonable justification.  Logically evaluates procedures and their effect on data.  Critically evaluates the effectiveness of collaboration and its impact on results/outcomes. | Demonstrates some depth and breadth of knowledge and understanding of a range of science inquiry skills and scientific concepts.  Applies science inquiry skills and scientific concepts mostly effectively in new and familiar contexts.  Logically explores and understands in some depth the interaction between science and society.  Communicates knowledge and understanding of scientific concepts, with mostly coherent and effective use of appropriate terms, conventions, and representations. |
| C | Deconstructs a problem and designs a considered and generally clear scientific investigation using a scientific method and/or engineering design process.  Obtains, records, and represents data, using generally appropriate procedures, conventions, and formats, with some errors but generally accurately and effectively.  Undertakes some analysis and interpretation of data and evidence to formulate generally appropriate conclusions with some justification.  Evaluates procedures and some of their effect on data.  Evaluates the effectiveness of collaboration and its impact on results/outcomes. | Demonstrates knowledge and understanding of a general range of science inquiry skills and scientific concepts.  Applies science inquiry skills and scientific concepts generally effectively in new or familiar contexts.  Explores and understands aspects of the interaction between science and society.  Communicates knowledge and understanding of scientific concepts, with generally effective use of appropriate terms, conventions, and representations. |

|  |  |  |
| --- | --- | --- |
| D | Prepares a basic deconstruction of a problem and an outline of a scientific investigation, using a scientific method and/or engineering design process.  Obtains, records, and represents data, using procedures, conventions, and formats inconsistently, with occasional accuracy and effectiveness.  Describes data and undertakes some basic interpretation to formulate a basic conclusion.  Attempts to evaluate procedures or suggest an effect on data.  Attempts to evaluate the effectiveness of collaboration and its impact on results/outcomes. | Demonstrates some basic knowledge and partial understanding of science inquiry skills and scientific concepts.  Applies some science inquiry skills and scientific concepts in familiar contexts.  Partially explores and recognises aspects of the interaction between science and society.  Communicates basic scientific information, using some appropriate terms, conventions, and/or representations. |
| E | Attempts a simple deconstruction of a problem and a procedure for a scientific investigation, using a scientific method and/or engineering design process.  Attempts to use some procedures and record and represent some data, with limited accuracy or effectiveness.  Attempts to describe results and/or interpret data to formulate a basic conclusion.  Acknowledges that procedures affect data.  Acknowledges the effectiveness of collaboration and its impact on results/outcomes. | Demonstrates limited recognition and awareness of science inquiry skills and/or scientific concepts.  Attempts to apply science inquiry skills and/or scientific concepts in familiar contexts.  Attempts to explore and identify an aspect of the interaction between science and society.  Attempts to communicate information about science. |

Assessment integrity

The SACE Assuring Assessment Integrity Policy outlines the principles and processes that teachers and assessors follow to assure the integrity of student assessments. This policy is available on the SACE website (www.sace.sa.edu.au) as part of the SACE Policy Framework.

The SACE Board uses a range of quality assurance processes so that the grades awarded for student achievement in the school assessment are applied consistently and fairly against the performance standards for a subject, and are comparable across all schools.

Information and guidelines on quality assurance in assessment at Stage 1 are available on the SACE website (www.sace.sa.edu.au).

Support materials

Subject-specific advice

Online support materials are provided for each subject and updated regularly on the SACE website (www.sace.sa.edu.au). Examples of support materials are sample learning and assessment plans, annotated assessment tasks, annotated student responses, and recommended resource materials.

Advice on ethical study and research

Advice for students and teachers on ethical study and research practices is available in the guidelines on the ethical conduct of research in the SACE on the SACE website (www.sace.sa.edu.au).