Scientific Studies

Subject Outline

Stage 1 and Stage 2

Version 2.0 – Draft for consultation
Ref: A582352
21 August – 29 September 2017

Government of South Australia

SACE Board of SA

CONTENTS

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 (STEM) thinking.

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, engineers, industry, and the wider community. Students are guided to engage in investigations that are relevant and of genuine interest, using either scientific methods or engineering design processes.

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 information and communication technology 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 the parts of 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.

Stage 1 Scientific Studies

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. 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 is a 10-credit subject or a 20-credit subject.

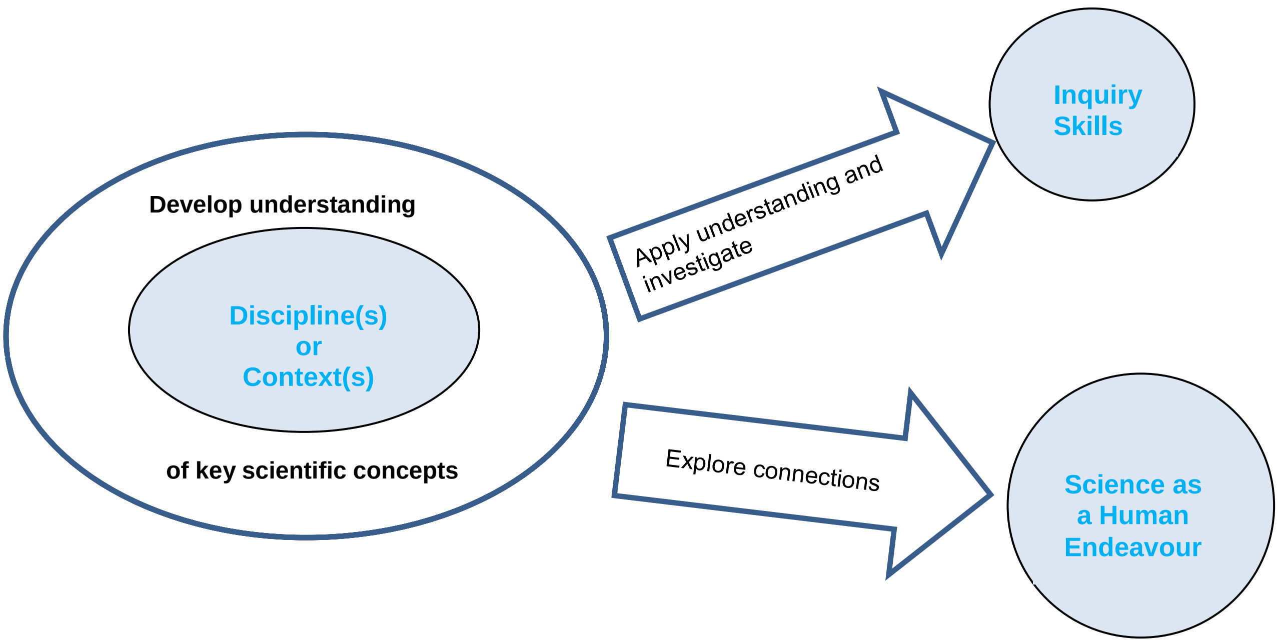
In Stage 1 Scientific Studies, scientific inquiry is the basis for developing integrated programs of learning through which students extend their skills, knowledge, and understanding of the three strands of science.

The three strands of science to be integrated throughout students learning are:

- science inquiry skills
- understanding of scientific concepts
- science as a human endeavour

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 science understanding.

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. Alternatively, contemporary scientific concepts such as contingent superorganisms, cycles, deep time, holism, powers of 10, sceptical empiricism, and randomness may be explored. Students may explore and extend their understanding of a range of science concepts relevant to the contexts they are studying, and investigate and apply their understanding of these concepts through the science inquiry skills. They 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 science 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.

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.

When undertaking their investigations, students, both individually and collaboratively, 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 science concepts form the basis of teaching, learning, and assessment in this subject.

Science Inquiry Skills

In Scientific Studies, investigation is an integral part of the learning and understanding of concepts, using scientific methods and/or the 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 all investigations.

	Scientific Methods	**Engineering Design Processes**
Observe, question, propose	Identify a **question**	Notice a **problem, need,** or **opportunity**
	Undertake background **research**	Undertake background **research**
	Formulate a **hypothesis**	Propose a **solution**
Plan, design, collate, analyse	State a **hypothesis** and Identify **variables** Design an **investigation procedure** to test a hypothesis	State a proposed **solution** and specify **requirements** Design a **model** or **prototype** to test a solution.
	Conduct trials, obtain and represent **data**	Conduct trials, obtain and represent **data**
	Analyse/interpret **data** and formulate **conclusions**	Analyse/interpret **data** and formulate **conclusions**
Reflect, evaluate, conclude, communicate	Evaluate **procedures**	Evaluate **models** or **prototypes**
	Both processes can be iterative 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 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, describe the limitations of the data and procedures, 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.

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.

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.

Science as a Human Endeavour

The *Science as a Human Endeavour* strand 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 science 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 science 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 and examples of ways of thinking about science as a human endeavour 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.
- Local, national, and international collaboration is often required in scientific investigation.

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.

Science Inquiry Skills

Through the exploration and application of the science inquiry skills and previous learning, students gain knowledge and understanding of scientific concepts and applications.

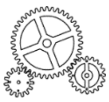
Students study a selection of science inquiry skills from the set of skills described in the pages that follow as well as a selection of science concepts relevant to the disciplines and/or contexts.

Students undertake various activities to develop their science inquiry skills, then use these learnt skills to analyse data and evaluate procedures in their own investigations using a scientific method or engineering design process. The explicit teaching of the science inquiry skills in contexts of interest to students enables students to apply these skills in investigations where the outcome may be uncertain, which leads to an enhancement of a student's science understanding in their chosen 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.

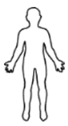
The possible contexts are suggestions for potential approaches, and are neither comprehensive nor exclusive. Teachers may select from these and are encouraged to consider other approaches according to local needs and interests.

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:

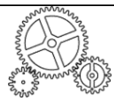


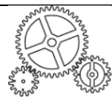
indicates a possible teaching and learning strategy for understanding a science inquiry skill

indicates a possible science inquiry activity

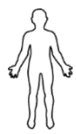
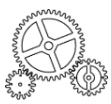


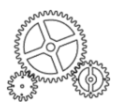
indicates a possible focus on science as a human endeavour.

Science Inquiry Skills	Possible Contexts	
Scientific Evidence Critical thinking allows claims and arguments to be analysed through empirical evidence, authority, logic, and intuition.	Discuss claim testers such as those described in the Big History Project: https://school.bighistoryproject.com/media/bhp3video/U1_BobBain_HowDoWeDecide.mp4	

Science Inquiry Skills	Possible Contexts	
• Apply claim testers to analyse the validity of claims.	Investigate claims made by advertisers and analyse the available evidence. Explore different types of scientific evidence identified in Compound Interest Chemistry: http://www.compoundchem.com/2015/04/09/scientific-evidence/	
	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.	
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 processes are shared in the application of scientific methods and engineering design. • Investigate different scientific methods. • Compare scientific methods to engineering design. Progress in science often requires refinement of procedures and repeated testing.	Discuss the iterative nature of scientific inquiry.	
	Construct flow charts to represent processes for scientific methods and design.	
	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 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)](http://indico.cern.ch/event/28617/contributions/1638133/attachments/531112/732392/aaas_feb08.pdf)	

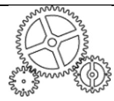
Science Inquiry Skills	Possible Contexts	
Observations Observations lead to the recognition of patterns and trends, the construction of meaning, the development of conclusions, or the development of further questions to investigate. Observations in science involve using the senses or instruments to acquire 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.	
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 synthesizing new knowledge. • Deconstruct a problem. Preliminary research leads to predictions.	Discuss ways to deconstruct a problem. Discuss aspects of testing ideas using, for example: http://undsci.berkeley.edu/article/scienceflowchart	
	Formulate questions and identify problems to investigate both individually and collaboratively. These may be developed but not investigated further. Useful website with free activities is Engage Scientific Enquiry: http://www.engagingscience.eu/en/scientific-enquiry/	
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	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	

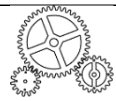
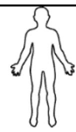
Science Inquiry Skills	Possible Contexts	
the outcome of an investigation. They can be altered, measured, and may be controlled in investigations. • Identify variables including; dependent, independent, controlled (and those that cannot be controlled). Scientifically designed procedures provide measureable 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	ethical risks.	
	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 adapting the method. Research, develop and trial method or design. 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/uploaded_files/CoPManagingRisksHazardousChemicals.pdf Develop safety audits using the example from Student RiskAssess brochure	
	Investigate the impacts of examples of scientific fraud using, for example, http://www.the-scientist.com/?articles.view/articleNo/33695/title/Top-Science-Scandals-of-2012/,	
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.	
	Practice techniques and safe use of apparatus. (Interactive Lab Primer) http://www.rsc.org/learn-chemistry/resource/res00001064/the-interactive-lab-	

Science Inquiry Skills	Possible Contexts	
	primer?cmpid=CMP00007674 Practice small scale laboratory techniques.	
	Discuss contributions of scientists who invented significant pieces of apparatus, or techniques (e.g. Robert Bunsen, Dr Heinrich Schnitger, John Severinghaus, or Florence B Seibert) and the impact their inventions have had on society.	
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 quadrant 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.	
	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.	
Representing data Tables, charts, and graphs can be used to: • Represent the results of investigations • 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. • 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 Discuss the advantages and disadvantages of different methods for representing data.	

<table>
<tr><th>Science Inquiry Skills</th><th>Possible Contexts</th><th></th></tr>
<tr><td rowspan="2">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 graphs.
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.</td><td>Practice constructing data tables, using, for example:
http://www.sedl.org/afterschool/toolkits/science/pdf/ast_sci_data_tables_sample.pdf
Beginners guide to graphing data:
https://www.youtube.com/watch?v=9BkbYeTC6Mo
Construct graphs:
• By hand
• Using software.</td><td></td></tr>
<tr><td>Discuss the misunderstandings that can result when data is presented in a misleading way. For example, 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.</td><td></td></tr>
</table>

Science Inquiry Skills	Possible Contexts	
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. 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.	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	
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.	Discussing 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.	
	Evaluate procedures and data sets provided to determine and hence comment on the limitations of possible conclusions.	

Science Inquiry Skills	Possible Contexts	
Conclusions Critical evaluation of procedures and data/outcomes can determine the meaningfulness of conclusions. • Selection and use of 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. Perform experiments to test an improvement to a procedure to determine if the conclusion can be altered.	 
Collaboration 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 group. Give students opportunities to discuss real world problems to develop critical and creative thinking skills.	
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 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.	
Communicating Science Science communication often requires complex concepts and terminology to be simplified into accessible ideas and	Discuss ways in which science is communicated to the public, using, for example, NOVA Science in the News	

Science Inquiry Skills	Possible Contexts	
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 infographics, for example: 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. The contributions of others are acknowledged though the use of appropriate citations • Acknowledge sources through recognised conventions. • Construct bibliographies and reference lists.	(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	
	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/ https://youtu.be/y66YKWz_sf0 Improve science communication skills using, for example, UBC Science Writing (https://www.youtube.com/channel/UCvynvmsn_NTIS9lc8cH-OFw) Use written, oral, and multimedia formats to communicate scientifically. Use, for example, presentation software such as https://prezi.com/ or https://www.powtoon.com/?edgetrackerid=10065846701972&gclid=COqbl-DRus4CFYNjvAodwscKkA Analyse referencing and/or footnoting in articles from different sources.	
	Investigate examples of peer review having significant impact. E.g. in the use of Thalidomide.	

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:

- two tasks with a focus on science inquiry skills
- one investigation with a focus on science as a human endeavour in the inquiry folio
- 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, including:
  - four tasks with a focus on science inquiry skills and
  - one longer or two shorter investigations with a focus on science as a human endeavour in the inquiry folio
- 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 Design of a scientific investigation.

IAE2 Obtaining evidence using appropriate procedures, and safe ethical working practices.

IAE3 Evaluation of procedures and results to formulate and justify conclusions.

IAE4 Representation and analysis of evidence to formulate and justify results.

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

Knowledge and Application

The specific features are as follows:

KA1 Development and application of scientific inquiry skills and understanding of scientific concepts in new and familiar contexts.

KA2 Exploration and understanding of the interaction between science and society.

KA3 Communication of knowledge and understanding of scientific concepts (and information) 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 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.

Tasks that extend science inquiry skills may include, for example:

- design practical investigations
- completion practical investigations
- prototype design and testing to find new solutions
- investigation of scientific claims
- analysing the accuracy of published data
- investigation of the accuracy of equipment or models
- investigation of scientific myths
- research 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 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 14 and 15, and may draw on an inquiry context or a discipline new context.

Students select and explore a recent discovery, innovation, issue, or advancement. 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 and justify their own conclusions.

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
- changes in government funding for science-related purposes, e.g. for scientific research into biotechnology, conservation planning, recycling, safe disposal of nuclear waste, energy supplies, engineering solutions.
- innovative directions in research.

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

- an introduction to identify the focus of the investigation and the aspect of science as a human endeavour that it links to
- relevant scientific concepts or background
- an explanation of how the focus of the investigation illustrates the interaction between science and society

- a discussion of the potential impact or application of the focus of the investigation, e.g. further development, effect on quality of life, environmental implications, economic impact, intrinsic interest
- a conclusion with justification
- citations and referencing.

For a 10-credit subject, the communication should be a maximum of 5 minutes if oral, 800 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 5 minutes if oral, 750 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.

This 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.

Collaborative Inquiry Design

Students collaborate to design and conduct an investigation for which the outcome is uncertain. The design may be based on the development of an investigation based on a hypothesis or the development of an innovative prototype to solve a real-world problem. The design enables students to extend their science inquiry skills by:

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

Students record individually, in a personal journal:

- initial thinking and ideas
- evidence of their own contribution to the project and supporting documentation on the application of their collaborative skills
- representation(s) of the data collected by the group
- preliminary analysis and interpretation of the results/outcome
- connections between results and scientific concepts.

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 should have a total of no more than sixteen A4 pages if written or the equivalent in multimodal form across the collaborative inquiry or inquiries.

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 may 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 data
- future planning
- peer review.

Collaborative Inquiry Evaluation

Students individually evaluate the collaborative inquiry, in the style of a pitch, defence, or justification.

This evaluation should include:

- a summary of the design and hypothesis
- an evaluation of the procedures and results/outcome
- an evaluation of the effectiveness of collaboration and its impact on results/outcomes
- a conclusion with justification and the consideration of possible limitations.

For a 10-credit subject, the pitch, defence, or justification should be a maximum of 3 minutes per student if oral or the equivalent if multimodal.

For a 20 credit subject, the pitch, defence, or justification 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 evidence may be, for example:

- conversation with their 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	Designs a logical, coherent, and detailed scientific investigation. Obtains evidence using appropriate procedures and safe ethical working practices accurately and highly effectively. Critically and logically evaluates procedures and results and formulates logical conclusions with detailed justification. Systematically and accurately represents and analyses evidence to formulate and justify results. Critically and perceptively evaluates the effectiveness of collaboration and its impact on results/outcomes.	Develops and applies scientific inquiry skills and understanding of scientific concepts (and information) highly effectively in new and familiar contexts. Critically explores and understands in depth the interaction between science and society. Communicates knowledge and understanding of science concepts coherently, with highly effective use of appropriate terms, conventions, and representations.
B	Designs a well-considered and clear scientific investigation. Obtains evidence using appropriate procedures and safe ethical working practices mostly accurately and effectively. Logically evaluates procedures and results and formulates suitable conclusions with justification. Mostly accurately represents and analyses evidence to formulate and justify results. Critically evaluates the effectiveness of collaboration and its impact on results/outcomes.	Develops and applies scientific inquiry skills and understanding of scientific concepts (and information) 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 science concepts mostly coherently, with effective use of appropriate terms, conventions, and representations.
C	Designs a considered and generally clear scientific investigation. Obtains evidence using generally appropriate procedures and safe ethical working practices with some errors but generally accurately and effectively. Evaluates procedures and results and formulates generally appropriate conclusions with some justification. Represents and analyses evidence to results with some justification. Evaluates the effectiveness of collaboration and its impact on results/outcomes.	Develops and applies scientific l inquiry skills and understanding of scientific concepts (and information) generally effectively in new or familiar contexts. Explores and understands aspects of the interaction between science and society. Communicates knowledge and understanding of science concepts generally effectively, using some appropriate terms, conventions, and representations.
D	Prepares the outline of a scientific investigation. Obtains some evidence using procedures and safe ethical working practices inconsistently, with occasional accuracy and effectiveness. Describes procedures and results with some basic interpretation and formulates a basic conclusion. Represents and describes evidence and formulates some results. Attempts to evaluate the effectiveness of collaboration and its impact on results/outcomes.	Develops and applies some scientific inquiry skills and understanding of scientific concepts (and information) 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.

	Investigation, Analysis, and Evaluation	Knowledge and Application
E	Identifies a simple procedure for a scientific investigation. Attempts to obtain evidence using some procedures and safe ethical practices, with limited accuracy or effectiveness. Attempts to describe results with limited interpretation of data and formulates a basic conclusion. Limited description of some evidence to present some basic results. Acknowledges the effectiveness of collaboration and its impact on results/outcomes.	Attempts to develop and apply scientific inquiry skills and understanding of scientific concepts (and information) 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).

Stage 2 Scientific Studies

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 2 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. 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

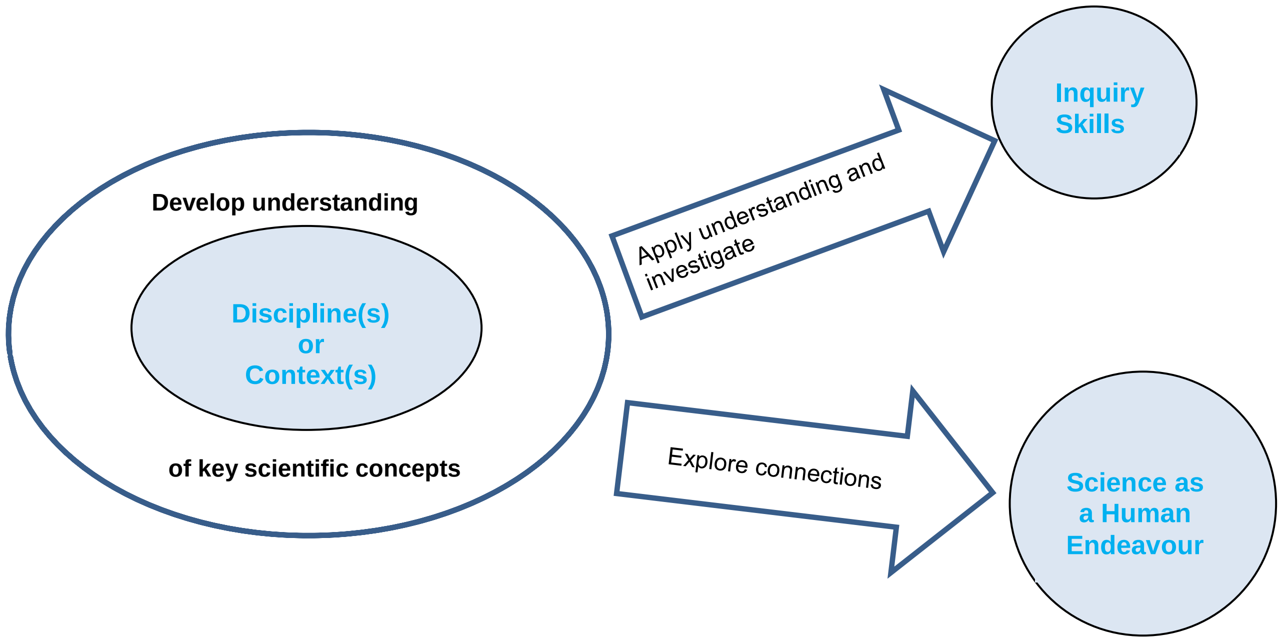
Stage 2 is a 20-credit subject.

In Stage 2 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:

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

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 science 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. Alternatively, contemporary scientific concepts such as contingent superorganisms, cycles, deep time, holism, powers of 10, sceptical empiricism, and randomness may be explored. Students may explore and extend their understanding of a range of science concepts relevant to the contexts they are studying, and investigate and apply their understanding of these concepts through the science inquiry skills. They 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 science concepts as the underlying focus.

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

In conjunction with both their investigations and the development of their understanding of key science 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.

When undertaking their investigations, students, both individually and collaboratively, 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 science 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 science concepts form the basis of teaching, learning, and assessment in this subject.

Science Inquiry Skills

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

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

	Scientific Inquiry	**Engineering Design**
Observe, question, propose	Identify a **question**	Notice a **problem, need,** or **opportunity**
	Undertake background **research**	Undertake background **research**
	Formulate a **hypothesis**	Propose a **solution**
Plan, design, collate, analyse	State a **hypothesis** and Identify **variables** Design an **investigation procedure** to test a hypothesis	State a proposed **solution** and specify **requirements** Design a **model** or **prototype** to test a solution.
	Conduct trials, obtain and represent **data**	Conduct trials, obtain and represent **data**
	Analyse/interpret **data** and formulate **conclusions**	Analyse/interpret **data** and formulate **conclusions**
Reflect, evaluate, conclude, communicate	Evaluate **procedures**	Evaluate **models** or **prototypes**
	Both processes can be iterative 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 need, develop 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, 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.

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

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 the evidence they obtain so that they can present and justify conclusions.

Science as a Human Endeavour

The *Science as a Human Endeavour* strand 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 science 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 science 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 and examples of ways of thinking about science as a human endeavour 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.
- Local, national, and international collaboration is often required in scientific investigation.

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.

Science Inquiry Skills

Through the exploration and application of the science inquiry skills and previous learning, students gain knowledge and understanding of scientific concepts and applications.

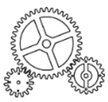
Students study a selection of science inquiry skills from the set of skills described in the pages that follow as well as a selection of science concepts relevant to the disciplines and/or contexts.

Students undertake various activities to develop their science inquiry skills, then use these learnt skills to analyse data and evaluate procedures in their own investigations using a scientific method or engineering design process. The explicit teaching of the science inquiry skills in contexts of interest to students enables students to apply these skills in investigations where the outcome may be uncertain, which leads to an enhancement of a student's science understanding in their chosen 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.

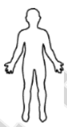
The possible contexts are suggestions for potential approaches, and are neither comprehensive nor exclusive. Teachers may select from these and are encouraged to consider other approaches according to local needs and interests.

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:

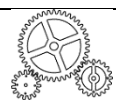


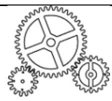
indicates a possible teaching and learning strategy for understanding a science inquiry skill

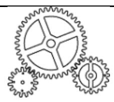
indicates a possible science inquiry activity

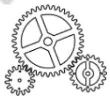


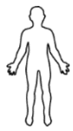
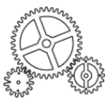
indicates a possible focus on science as a human endeavour.

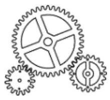
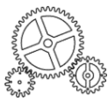
Science Inquiry Skills	Possible Contexts	
Scientific Evidence Critical thinking allows claims and arguments to be analysed through empirical evidence, authority, logic,	Discuss claim testers such as those described Big History Project: Investigate claims made by advertisers	

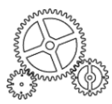
Science Inquiry Skills	Possible Contexts	
and intuition. • Apply claim testers to analyse the validity of claims.	and analyse the available evidence. Explore different types of scientific evidence identified in Compound Interest Chemistry: http://www.compoundchem.com/2015/04/09/scientific-evidence/	
	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.	
Approaches to science and engineering Progress in science is often advanced through engineered solutions, while technology and engineering develop through creative applications of	Discuss the iterative nature of scientific inquiry.	
	Construct flow charts to represent processes for scientific methods and design.	

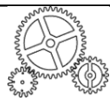
Science Inquiry Skills	Possible Contexts	
science. Many processes are shared in the application of scientific methods and engineering design. • Investigate different scientific methods. • Compare scientific methods to engineering design processes. Progress in science often requires refinement of procedures and repeated testing.	Investigate examples of progress in science and engineering made through: • Serendipitous discovery https://www.gizmodo.com.au/2013/11/24-accidental-scientific-discoveries-that-changed-the-world/ Henrietta Leavitt http://undsci.berkeley.edu/article/0_0_0/whatisscience_02 • 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/whathasssciencedone_03 Discuss the importance of international collaboration e.g. involving the Square Kilometre Array (http://www.ska.gov.au/Pages/default.aspx)	
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. Assess differences in a range of physical characteristics using images from SA seedbank: http://saseedbank.com.au/art_display.php or http://saseedbank.com.au/	
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	Discuss ways to deconstruct a problem. Discuss aspects of testing ideas using, for example: using, for example: http://undsci.berkeley.edu/article/scienceflowchart	

Science Inquiry Skills	Possible Contexts	
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 synthesizing new knowledge. • Deconstruct a problem. Preliminary research leads to predictions.	http://undsci.berkeley.edu/article/0_0_0/think_science	
	Formulate questions and identify problems to investigate both individually and collaboratively. These may be developed but not investigated further. Useful website with free activities is Engage Scientific Enquiry: http://www.engagingscience.eu/en/scientific-enquiry/	
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 variables including; dependent, independent, controlled (and those that cannot be controlled). Scientifically designed procedures provide measureable evidence. • Design procedures to investigate observations, questions, and problems. • Design and construct testable models and prototypes. Materials are required to implement scientific 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 http://undsci.berkeley.edu/article/0_0_0/sciencetoolkit_06 Use scenarios to explore safety and ethical risks.	
	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 adapting the method. Research, develop and trial method or design. Improve an existing procedure or	

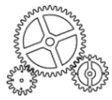
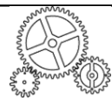
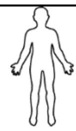
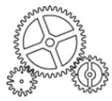
Science Inquiry Skills	Possible Contexts	
• Identify required materials. Safety and ethics are essential in any scientific investigation. • Identify safety and ethical considerations. Investigations often require iterative or non-sequential approaches. Recommend and/or undertake subsequent or related investigations	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/uploaded_files/CoPManagingRisksHazardousChemicals.pdf Develop safety audits using the example from Student RiskAssess brochure	
	Investigate the impacts of examples of scientific fraud using, for example, http://www.neatorama.com/2006/09/19/10scientific-frauds-that-rocked-the-world/, or http://listverse.com/2008/04/09/top-10-scientific-frauds-and-hoaxes/	
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.	
	Practice techniques and safe use of apparatus. (Interactive Lab Primer) http://www.rsc.org/learn-chemistry/resource/res00001064/the-interactive-lab-primer?cmpid=CMP00007674 Practice small scale laboratory techniques.	
	Discuss contributions of scientists who invented significant pieces of apparatus, or techniques (e.g. Dr Jonas Salk, Andre-Marie Ampere, Stephanie Kwolek, Zacharias Janssen, Ann Tsukamoto) and the impact their inventions have had on society.	
Collecting data Observations allow for the collection and recording of data that is both	Investigate how qualitative and quantitative data can be collected such as measuring plant population density	

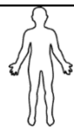
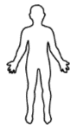
Science Inquiry Skills	Possible Contexts	
qualitative and quantitative. Quantitative data can be generated from qualitative data. • Distinguish between qualitative and quantitative data. • Collect and record examples of qualitative and quantitative data. • Generate quantitative data from appropriate sources of qualitative data.	using the quadrant 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.	
	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.	
Different types of 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. Different types of data can be analysed and represented in different ways: continuous, discrete and categorical data. • Classify data as continuous, discrete or categorical.	Discuss the advantages and disadvantages of different types of data.	
	Investigate examples of different types of data using e.g. http://www.bbc.co.uk/bitesize/ks3/science/organisms_behaviour_health/variation_classification/revision/3/ http://www.ase.org.uk/documents/language-of-mathematics-in-science-1/	
Representing data Tables, charts, and graphs can be used to: • Represent the results of investigations • 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. • 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 Discuss the advantages and disadvantages of different methods for representing data.	

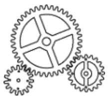
Science Inquiry Skills	Possible Contexts	
Tables can be used to organise and process raw data. • Use tables to organise and process raw data. Data can be represented visually as charts graphs and diagrams, including; pie charts, bar graphs, line graphs and scatter graphs. Visually displaying data can 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.	Practice constructing data tables, using, for example: http://www.sedl.org/afterschool/toolkits/science/pdf/ast_sci_data_tables_sample.pdf Beginners guide to graphing data: https://www.youtube.com/watch?v=9BkbYeTC6Mo Construct graphs: • by hand https://www.youtube.com/watch?v=GUYRMdcEs00 • using software https://www.youtube.com/watch?v=yvYvHU83_6Y	
	Discuss the misunderstandings that can result when data is presented in a misleading way. For example, by using an inappropriate scale. Useful website: https://www.khanacademy.org/math/pre-algebra/pre-algebra-math-reasoning/pre-algebra-frequency-dot-plot/v/misleading-line-graphs Explore claims made using data inappropriately in food advertising. http://undsci.berkeley.edu/article/0_0_0/sciencetoolkit_02	
Describing relationships The shape of a graph shows the relationship between the variables. Linear relationships are represented in graphs as straight lines. • Determine whether graphed variables are linear or non-linear. Proportional values are related by a constant multiplier. Directly proportional relationships in a graph can be represented by a straight line that passes through the origin. • Distinguish between variables that	Discuss the interpretation of graphs in Science, e.g. using: http://www.visionlearning.com/en/library/Process-of-Science/49/Using-Graphs-and-Visual-Data-in-Science/156	
	Use examples from Chapter 7 http://www.ase.org.uk/documents/language-of-mathematics-in-science-1/ to: • Determine trends and relationships in graphed data. • Calculate slope of a line on graphed data.	

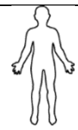
Science Inquiry Skills	Possible Contexts	
are directly proportional and inversely proportional. • Determine whether graphed variables are directly proportional. The gradient of a graphed line can be used to interpret relationships such as rate. • Calculate the slope of a line or tangent, if approprpriate.		
Using graphs to make predictions On a graph, interpolation involves estimating values form within the range of the data set. Extrapolation involves estimating data points from beyond the range of the data set. • Predict values on graphs through interpolation and extrapolation	Discuss when it is and is not appropriate to extrapolate to make predictions from graphs.	
	Develop skills in interpolating and extrapolating graphs to make predictions using real or simulated data for example from CSIRO or the Australian Bureau of Statistics (ABS).	
	Explore ways in which the extrapolation of data can be used to make predictions which impact on society, for example, for taking action on climate change.	
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. Scatter indicates the presence of random errors. • Identify sources of random error in an investigation. The precision of results depends on how well random errors are controlled. • Identify, when comparing sets of data, which is more precise. The design of an experiment should minimise the effects of random errors.	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://www.e-education.psu.edu/geog486/node/1890 http://www.bing.com/search?q=data+uncertainty&qs=n&sp=-1&pq=data+uncertainty&sc=1-16&sk=&cvid=68137FB018A54F5F8E9F7D22454846C9&first=11&FORM=PORE	

Science Inquiry Skills	Possible Contexts	
• Describe the effect of increasing the sample size in an investigation. Variation from the true value (if obtainable) may be used to indicate the accuracy of the investigation. • Compare values obtained with expected values or trends (in graphs). 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. An outlier is a value in a set of data that is recognised as an anomaly. Outliers may be the result of mistakes. • Identify outliers in data sets.		
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. An outcome that appears to be a 'failure' provides opportunities for learning and refinement of models or procedures.	Discussing 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. Discuss the role of failure in the progress of science. Useful websites: https://blogs.scientificamerican.com/guest-blog/failure-in-science-is-frequent-and-inevitable-and-we-should-talk-more-about-it/ http://www.sciencefriday.com/segments/why-science-needs-failure-to-succeed/ http://www.mprnews.org/story/2015/04/17/bcst-friday-roundtable-failure	
Conclusions Critical evaluation of procedures and data/outcomes can determine the	Evaluate procedures and data sets provided by the teacher to determine and hence comment on the limitations of possible conclusions.	

Science Inquiry Skills	Possible Contexts	
meaningfulness of conclusions. • Selection and use of 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.	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. Perform experiments to test an improvement to a procedure to determine if the conclusion can be altered.	
Collaboration 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 group. Give students opportunities to discuss real world problems to develop critical and creative thinking skills.	
Scientific models and mathematical equations Many mathematical relationships in science can be modelled by equations and formulae. Mathematical equations and scientific formulae contain variables that may be manipulated. • Express equations and formulae in varying arrangements. • Manipulate mathematical relationships. • Calculate values using mathematical relationships. • Manipulate units in calculations.	Study formulae applied in different science disciplines and mathematics. Practise rearranging simple equations with the assistance of strategies such as formulae triangles. Construct chemical formulae and equations.	 
	Determine the origin or derivation of units for various scientific quantities.	
	Clarify understanding of significant figures. https://www.khanacademy.org/math/algebrapre-/decimals-pre-alg/sig-figs-pre-alg/v/significant-figures	
Significant figures, resolution and rounding in calculations	Develop skills by practicing identifying significant figures, e.g. using: https://www.khanacademy.org/math/ari	

Science Inquiry Skills	Possible Contexts	
Measurements are limited by the resolution of the instrument or apparatus. The scale that is available defines the number of significant figures that can be read and recorded. • Identify the resolution available in a measurement. • Select instruments of appropriate resolution. Significant figures are related to the number of digits that contribute information about the size of the value. • Represent data and the results of calculations to an appropriate number of significant figures. For a set of values used in a calculation, calculated values should reflect the lowest resolution available. • Round values at appropriate stages during calculations.	thmetic-home/arith-review-decimals/arithmetic-significant-figures-tutorial/e/significant_figures_1 Examine various pieces of equipment to determine resolution.	
	Discuss the importance of significant figures when measuring very small quantities. For example, when measuring concentrations of pollutants in air, water, body fluids, etc.	
	Apply and interconvert using units and prefixes using data from, e.g. problem sets in Science Primer: http://scienceprimer.com/metric-unit-prefixes	
SI prefixes and units Very large or small values may be more effectively expressed using prefixes or scientific notation. • Express values using prefixes and interconvert between prefixes. • Express values using scientific notation. A unit of measurement is a standard used in measuring and identifying a quantity. • Apply appropriate units to data and calculated values.	Discuss the significance of the General Conferences on Weights and Measures. Useful website: http://physics.nist.gov/cuu/Units/history.html Discuss the failure of Mars orbiter due to incorrect use of units: http://edition.cnn.com/TECH/space/9909/30/mars.metric.02/	
	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.	

Science Inquiry Skills	Possible Contexts	
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 clearly labelled. • Draw and label accurate representations of scientific apparatus.	Discuss ways in which science is communicated to the public, using, for example, Australia's Science Channel (https://www.australiascience.tv/) 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	
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: animations, simulations, videos, interviews, presentations, and images. Scientific findings often undergo peer	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/ https://youtu.be/y66YKWz_sf0 Improve science communication skills using, for example, UBC Science Writing (https://www.youtube.com/channel/UCvynvmsn_NTlS9lc8cH-OFw) Use written, oral, and multimedia formats to communicate scientifically. Use, for example, presentation software such as https://prezi.com/ or https://www.powtoon.com/?edgetracker id=10065846701972&gclid=COqbl-DRus4CFYNjvAodwscKkA Analyse referencing and/or footnoting in articles from different sources.	

Science Inquiry Skills	Possible Contexts	
review and scrutiny to increase credibility. • Select and acknowledge peer reviewed sources. • Participate in a peer review of written and/or electronic submissions. The contributions of others are acknowledged though the use of appropriate citations • Acknowledge sources through recognised conventions. • Construct bibliographies and reference lists.	Investigate examples of peer review having significant impact e.g. stem cell research: http://science.howstuffworks.com/innovation/scientific-experiments/scientific-peer-review.htm	

ASSESSMENT SCOPE AND REQUIREMENTS

All Stage 2 subjects have a school assessment component and an external assessment component.

EVIDENCE OF LEARNING

The following assessment types enable students to demonstrate their learning in Stage 2 Scientific Studies.

School Assessment (70%)

- Assessment Type 1: Inquiry Folio
- Assessment Type 2: Collaborative Inquiry

External Assessment (30%)

- Assessment Type 3: Individual Inquiry (30%).

Students provide evidence of their learning through seven assessments, including the external assessment. Students complete:

- one inquiry folio, including:
  - one individual inquiry design proposal
  - one investigation with a focus on science as a human endeavor
  - three tasks with a focus on science inquiry skills
- one collaborative inquiry
- one individual inquiry.

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
- teachers and assessors to 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 and assessors 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 Design of a scientific investigation.

IAE2 Obtaining evidence using appropriate procedures, and safe ethical working practices.

IAE3 Evaluation of procedures and results to formulate and justify conclusions.

IAE4 Representation and analysis of evidence to formulate and justify results.

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

Knowledge and Application

The specific features are as follows:

KA1 Development and application of scientific inquiry skills and understanding of scientific concepts in new and familiar contexts.

KA2 Exploration and understanding of the interaction between science and society.

KA3 Communication of knowledge and understanding of scientific concepts (and information) using appropriate terms, conventions, and representations.

SCHOOL ASSESSMENT

Assessment Type 1: Inquiry Folio (50%)

Students undertake:

- three tasks with a focus on science inquiry skills
- one investigation with a focus on science as a human endeavour
- one individual investigation inquiry design proposal.

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 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.

Tasks that extend science inquiry skills may include, for example:

- design practical investigations
- completion practical investigations
- design or modify models or prototypes to find new solutions to problems
- investigation of scientific claims
- analysing the accuracy of published data
- investigation of the accuracy of equipment or models
- investigation of scientific myths
- research 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.

The set of science inquiry skills tasks should be a maximum of 12 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 42 and 43, and may draw on an inquiry context or a discipline new context.

Students select and explore a recent discovery, innovation, issue, or advancement. 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 and justify their own conclusions.

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
- changes in government funding for science-related purposes, e.g. for scientific research into biotechnology, conservation planning, recycling, safe disposal of nuclear waste, energy supplies, engineering solutions.
- innovative directions in research.

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

- an introduction to identify the focus of the investigation and the aspect of science as a human endeavour that it links to
- relevant scientific concepts or background
- an explanation of how the focus of the investigation illustrates the interaction between science and society
- a discussion of the potential impact or application of the focus of the investigation, e.g. further development, effect on quality of life, environmental implications, economic impact, intrinsic interest
- a conclusion with justification
- citations and referencing.

The scientific communication should be a maximum of 6 minutes for an oral presentation, 1000 words if written, or the equivalent in multimodal form.

This 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.

Individual Inquiry Design Proposal

In readiness for their external assessment, students individually prepare a proposal for an investigation for which the outcome is unknown. The proposal will form the basis of Assessment Type 3: Individual Inquiry. Students may use a scientific method or engineering design process.

The design proposal includes:

- a statement of an investigable question or hypothesis, problem, or need, or opportunity depending on whether the student chooses to use a scientific method or engineering design.
- identification and discussion of all variables
- an outline (with reasons) of the proposed research approach or method, or engineering design of a model
- a plan for conducting the research.

Students should be encouraged to be innovative in their inquiry and understand that the risk of an unexpected outcome is not a failure but an inherent part of scientific investigation.

The proposal is assessed and feedback is given before the student begins the Assessment Type 3: Individual Inquiry.

The design proposal should be a maximum of 3 minutes if oral, 500 words if written, or the equivalent in multimodal form.

The proposal could take the form of, for example:

- a concept map
- flow charts
- an oral or multimodal presentation
- a science grant application

The teacher should provide feedback to students on their individual inquiry design proposal and improvements made as a result of the feedback should be reflected in the final report for Assessment Type 3: Individual Inquiry.

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 (20%)

Students undertake one collaborative inquiry.

Collaborative Inquiry Design

Students collaborate to design and conduct an investigation for which the outcome is uncertain. The design may be based on the development of an investigation based on a hypothesis or the development of an innovative prototype to solve a real-world problem. The design enables students to extend their science inquiry skills by:

- deconstructing the parts of 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.

Students record individually, in a personal journal:

- initial thinking and ideas
- evidence of their own contribution to the project and supporting documentation on the application of their collaborative skills
- representation(s) of the data collected by the group
- preliminary analysis and interpretation of data
- connections between results and scientific concepts.

The personal journal should have no more than twelve 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 journal represents the work and critical thinking of the student.

The journal may 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 data
- future planning
- peer review.

Collaborative Inquiry Evaluation

Students individually evaluate the collaborative inquiry, in the style of a pitch, defence, or justification.

This evaluation should include:

- a summary of the design and hypothesis
- an evaluation of the procedures and results/outcome
- an evaluation of the effectiveness of collaboration and its impact on results/outcomes
- a conclusion with justification and the consideration of possible limitations.

The pitch, defence, or justification should be a maximum of 5 minutes per student if oral or the equivalent if multimodal.

The format may be, for example:

- conversation with their 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.

EXTERNAL ASSESSMENT

Assessment Type 3: Individual Inquiry (30%)

Students undertake one individual inquiry using the proposal developed and assessed in Assessment Type 1: Inquiry Folio. Students use the design proposal (incorporating changes made as a result of the feedback, if appropriate) from Assessment Type 1: Inquiry Folio to conduct a practical investigation for which the outcome is uncertain. Students may use a scientific method or engineering design process conduct an investigation based on a question, problem, need, or opportunity identified by each individual.

Students present an individual report that summarises the proposal, identifies any modifications made to the procedure as a result of feedback from the teacher, analyses the data obtained, and evaluates the method or model(s) development used. If the results are unexpected, the student discusses the reasons for these results as part of their evaluation.

The individual inquiry has three parts:

- the design proposal undertaken as a part of the school assessed tasks for Assessment Type 1: Inquiry Folio. *This is part of the school assessment and is not assessed with the external assessment.*
- the practical investigation
- a report of the finding of the investigation.

The report includes:

- introduction providing the basis for the investigation
- summary of the design of the investigation including the hypothesis or solution and modifications as a result of feedback
- results of the practical investigation, analysis of the results, identification of trends and linking results to relevant discipline knowledge
- evaluation of the method/model used
- identification of sources of uncertainty
- conclusion with justification and consideration of the limitations of the investigation.
- citations and referencing.

The combined word count for the individual investigation report should be a maximum of 1500 words, if written, or the equivalent in multimodal form. It is anticipated that students will submit their report electronically.

The following specific features of the assessment design criteria for this subject are assessed in the Individual Inquiry:

- investigation, analysis, and evaluation – IAE3, IAE4
- knowledge and application – KA1, KA3.

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 and assessors 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.

The student's school assessment and external assessment are combined for a final result, which is reported as a grade between A+ and E–.

Stage 2 Scientific Studies Performance Standards

	Investigation, Analysis, and Evaluation	Knowledge and Application
A	Designs a logical, coherent, and detailed scientific investigation. Obtains evidence using appropriate procedures and safe ethical working practices accurately and highly effectively. Critically and logically evaluates procedures and results and formulates logical conclusions with detailed justification. Systematically and accurately represents and analyses evidence to formulate and justify results. Critically and perceptively evaluates the effectiveness of collaboration and its impact on results/outcomes.	Develops and applies scientific inquiry skills and understanding of 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 science concepts (and information) coherently, with highly effective use of appropriate terms, conventions, and representations.
B	Designs a well-considered and clear scientific investigation. Obtains evidence using appropriate procedures and safe ethical working practices mostly accurately and effectively. Logically evaluates procedures and results and formulates suitable conclusions with justification. Mostly accurately represents and analyses evidence to formulate and justify results. Critically evaluates the effectiveness of collaboration and its impact on results/outcomes.	Develops and applies scientific inquiry skills and understanding of 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 science concepts (and information) mostly coherently, with effective use of appropriate terms, conventions, and representations.
C	Designs a considered and generally clear scientific investigation. Obtains evidence using generally appropriate procedures and safe ethical working practices with some errors but generally accurately and effectively. Evaluates procedures and results and formulates generally appropriate conclusions with some justification. Represents and analyses evidence to formulate results with some justification. Evaluates the effectiveness of collaboration and its impact on results/outcomes.	Develops and applies scientific l inquiry skills and understanding of 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 science concepts (and information) generally effectively, using some appropriate terms, conventions, and representations.
D	Prepares the outline of a scientific investigation. Obtains some evidence using procedures and safe ethical working practices inconsistently, with occasional accuracy and effectiveness. Describes procedures and results with some basic interpretation and formulates a basic conclusion. Represents and describes evidence to formulate some results. Attempts to evaluate the effectiveness of collaboration and its impact on results/outcomes.	Develops and applies some scientific inquiry skills and understanding of 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	Identifies a simple procedure for a scientific investigation. Attempts to obtain evidence using some procedures and safe ethical practices, with limited accuracy or effectiveness. Attempts to describe results with limited interpretation of data and formulates a basic conclusion. Limited description of some evidence to present some basic results Acknowledges the effectiveness of collaboration and its impact on results/outcomes.	Attempts to develop and apply scientific inquiry skills and understanding of 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 both the school assessment and the external 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 2 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).