 Module 1 – observations as evidence

Year 11 investigating science 2018

Duration – 6-8 hours

Description of unit

All scientific investigations rely on detailed, accurate observations and measurements. The collection of primary, qualitative and quantitative data allow scientists to formulate ideas, describe their observations, find relationships and pose questions for further investigation. Understanding and using the scientific process ensures that investigations are valid, accurate and reliable and can withstand testing and evaluation. Students ask and pose questions to investigate, make predictions and gather scientific evidence. They plan practical investigations that involve formulating hypotheses, determining independent, dependent and controlled variables and assessing risks. Students explore how the tools used for observation and technologies available can affect the kind of data collected.

This document references the [Investigating Science Stage 6 Syllabus](https://syllabus.nesa.nsw.edu.au/investigating-science-stage6/) © 2017 NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales.

Inquiry question

How does primary data provide evidence for further investigation?

Please note that Working Scientifically outcomes in the sample unit of work are represented with the letters WS to differentiate from the content descriptors.

Working Scientifically outcomes

Students develop questions and hypotheses for scientific investigation. They focus on selecting appropriate materials and technologies to collect primary data, follow the scientific process and conduct experiments safely and accurately. Students evaluate and modify investigations in response to new evidence or observations, suggest improvements and propose questions for further investigations.

A student:

* INS11/12-1 develops and evaluates questions and hypotheses for scientific investigation
* INS11/12-2 designs and evaluates investigations in order to obtain primary and secondary data and information
* INS11/12-3 conducts investigations to collect valid and reliable primary and secondary data and information
* INS11/12-4 selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
* INS11/12-7 communicates scientific understanding using suitable language and terminology for a specific audience or purpose

Knowledge and Understanding outcome

A student:

* INS11-8 identifies that the collection of primary and secondary data initiates scientific investigations

Assessment – depth study (4 hours) – soaps, shampoos and detergents

| Outcomes/content | Teaching and learning | Evidence of learning |
| --- | --- | --- |
| Students:* use data gathered to plan a practical investigation to:
	+ pose further questions that will be investigated

WS INS11/12-1* + develop and evaluate inquiry questions and hypotheses to identify a concept that can be investigated scientifically, involving primary and secondary data
 | Citizen scientistsInvestigate reasons for the increased popularity of citizen science programs. Some ideas for why they are popular might include:* uses the scientific method of asking questions about the natural world and collecting data systematically to address the question.
* engages volunteers and the public in scientific research projects. e.g. CoralWatch, Reef Guardians, Eye on the Reef, Seagrass-Watch, Healthy Waterways, Streamwatch, ReefBlitz, Earthwatch and Climatewatch
* provides public benefits such as heightens public awareness of environmental issues and the effects of tourism, promotes greater scientific literacy of public
* allows scientists to gather data over time and across large geographic areas to answer significant research questions.
* investigate some of the projects at:
* [Citizen Science](http://www.environment.nsw.gov.au/research-and-publications/your-research/citizen-science)
* [Zooniverse](https://www.zooniverse.org/)

Being a Citizen ScientistDiscuss your students could become citizen scientists in their own school or community. How could we develop our own Citizen Science project at school? Students might:* conduct a Biodiversity Blitz around the school playground or for a chosen field study area. Observe and record the number and variety of plant and animal species in the location. Compare findings with [Atlas of Living Australia](https://www.ala.org.au/explore-by-location/)
* undertake [water quality](http://www.environment.nsw.gov.au/water/waterqual.htm) testing in local water sources
* undertake vegetation sampling and soil testing in a defined area

From these observations, pose possible questions that could be investigated and plan a citizen science project such as:* design a weed control project to remove a noxious weed from the school oval
* plan a project to increase native vegetation around the school to attract native birds to the area
* design a program to prevent mosquito breeding by reducing water ponding
* design a project which creates awareness about being water wise, identifying ways to reduce water usage and wastage around the school
* plan a project to reduce the carp population in the local river
 | * Describe how the data is collected in a selected citizen science project.
* Discuss the importance of collecting a large amount of reliable data. (This provides a large sample size in the database to use.)
* Pose a number of questions that could be investigated based on data collected in a selected citizen science project.
* Formative assessment task:
* Observations as evidence for further investigation – produce and display a concept map for one of the Citizen Scientist projects, linking observations made with possible questions for further investigation.

Our Citizen Science Project* Use [citizen science](http://www.environment.nsw.gov.au/research-and-publications/your-research/citizen-science) to plan a project and present to the class.
* This activity could form the basis of a depth study.
 |
| Students:* use data gathered to plan a practical investigation to:
	+ pose further questions that will be investigated
	+ discuss the role of variables
	+ determine the independent and dependent variables
	+ formulate a hypothesis that links the independent and dependent variables
	+ describe at least three variables that should be controlled in order to increase the validity of the investigation

WS INS11/12-1* + develop and evaluate inquiry questions and hypotheses to identify a concept that can be investigated scientifically, involving primary and secondary data

WS INS11/12-2* + assess risks, consider ethical issues and select appropriate materials and technologies when designing and planning an investigation

WS INS11/12-7* + select and use suitable forms of digital, visual, written and/or oral forms of communication
 | Engaging* teacher demonstration of one of the activities below (or your own)
* discuss independent, dependent and controlled variables
* features of fair testing
* students identify a question, based on the demonstration, that they will investigate, formulate a hypothesis that links the independent and dependent variables and state variables that need to be controlled
* students plan and conduct their experiment and report back to the class.

ORuse data gathered from inquiry questions 1 and 2, to develop possible further questions that could be investigated.Gathering DataGather data to test a hypothesis made, in a chosen simple experiment. A number of activities are suggested. Teachers may choose one of the following:* construct a paper whirlybird to fall the slowest or land on a target
* build a water-powered rocket that, when launched, reaches the greatest height
* design a film-canister rocket that reaches the greatest height
* design and [build a catapult](http://meprogram.com.au/wp-content/uploads/2016/03/CC-ME-Catapult-curriculum-resources.pdf)
* design a [simple hovercraft](http://meprogram.com.au/wp-content/uploads/2016/03/CC-ME-Hovercraft-curriculum-resources.pdf)
* compare the voltage obtained from a thermocouple made with different metal and alloy pairs
* build a balloon-powered or mouse-trap powered car
* measure the resistance of different lengths of graphite (pencil leads) or different types of graphite
* investigate the physical properties of polymers such as strength, moisture absorbency, UV stability, elasticity
* design a ‘super fertiliser-food’ for plants to promote germination and growth from seed
* investigate the [energy output of a solar panel](http://seniorphysics.com/physics/eei.html) – consider the independent variables of angle of incident light, amount of shade/light intensity, layers of cellophane or shade cloth, wavelength/frequency of light on the amount of current produced
* investigate the effectiveness of different liquid soaps as antibacterial washes
* test the effect of solutions of varying acidity on ‘teeth’(pieces of calcium carbonate) and compare with soft drinks
* test the effect of pH on the strength of hair (keratin) and relate to shampoo
* investigate the properties of a simple battery. Construct a voltaic pile or galvanic cell and describe the essential components of a cell, including the characteristics of the electrolyte and factors affecting battery efficiency. This may lead to a depth study in the use of batteries in wearable technologies, medical monitoring, flexible devices and energy storage for large scale renewable energy farms
 | During this module, students are to maintain a learning journal documenting their investigations. This journal may include written, video or photographic records of their work. Students should show modifications made, evidence of teacher feedback and student evaluation.Formative Assessment* Oral report to class:
	+ describing the question they were investigating
	+ stating the hypothesis formulated (linking the independent and dependent variables)
	+ identifying controlled variables in their experiment
	+ describing what they found
	+ stating how this investigation has built on what we already knew (what ‘new information’ we now have)

Students then complete a reflection checklist (see attached).Investigation Roundup:* Each group of students researches and presents an actual research project (video/science report) that has been done by a named scientist. Other students in the class identify the independent and dependent variables and list the variables that would need to be controlled. May do as a Think-Pair-Share activity.
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| WS INS11/12-1* + modify questions and hypotheses to reflect new evidence

WS INS11/12-2* + evaluate and modify and investigation in response to new evidence
 | Posing further questionsPlan a further (more sophisticated) investigation to build on the experiment done above or an investigation from inquiry questions 1 and 2. | Present a report on their investigation, including:* authentic recording of observations, planning, design and testing in their learning journal
* initial data collected
* the hypothesis tested that links the independent and dependent variables
* the controlled variables
* correctly labelled, scientific diagrams
* results
* suggest ideas for further investigations and the data that would need to be collected

OrTeachers may ask students to present their investigation as a visual report or in a flowchart. |
| Students:* develop a method to collect primary data for a practical investigation by:
	+ describing how to change the independent variable
	+ determining the characteristics of the measurements that will form the dependent variable
	+ describing how the data will be collected
	+ describing how the controlled variables will be made consistent
	+ describing how risks can be minimised

WS INS11/12-1* + develop and evaluate inquiry questions and hypotheses to identify a concept that can be investigated scientifically, involving primary and secondary data

WS INS11/12-3* + employ and evaluate safe work practices and manage risks

WS INS11/12-4* + apply quantitative processes where appropriate

WS INS11/12-7* + select and use suitable forms of digital, visual, written and/or oral forms of communication
 | Great stories in scienceExplore some of the stories of great scientific discoveries and discuss the scientific methods used in their research, such as:* [Marie Curie](https://www.nobelprize.org/nobel_prizes/themes/physics/curie/)
* [Charles Darwin](https://www.youtube.com/watch?v=WAKppAtIeh8)
* [Wilhelm Rontgen](https://www.famousscientists.org/wilhelm-rontgen/)

Developing a method to collect dataDiscuss the features of a scientific method.Design a method to collect primary data and conduct a simple experiment which identifies the independent, dependent and controlled variables in the investigation. Teachers may choose to further develop an investigation from inquiry questions 1 and 2 or consider a new investigation. Possible experiments could be:* the effect of particle size on rates of reaction
* ball compression and bounce height
* measuring the coefficient of restitution for different balls
* measuring factors affecting the rate at which different substances dissolve in water
* the effect of different surfaces on the speed of a rolling ball
* comparing the rate at which capsules, tablets, enteric-coated tablets, and slow-release tablets dissolve
* testing the effectiveness of antibacterial cleaning agents
* construct an efficient solar hot-water heater
* designing and testing a water filtration unit

Finding out about current researchResearch at least one example of current scientific research.Explain how these scientists collect, measure and record data.Use ideas gathered to reflect on their own method. Students may consider the validity, reliability and accuracy of the method they have developed.Implementing the methodBased on feedback received from peers and their teacher, students evaluate and refine their method.Students complete an investigation planning sheet and have it checked before conducting the experiment.Investigation planning sheet - see resources. | Project ProposalStudents present an ‘abstract’ about their research. They must present a written outline of their project and oral report to the ‘Research Board’ (students in the class) to convince the Board to fund their project.They need to provide:* the question to be investigated
* the independent variable and describe how it will be changed
* the dependent variable and describe how it will be measured
* their hypothesis linking the independent and dependent variables
* the controlled variables and describe how they will be made consistent
* the data that will be collected
* how the data will be collected
* how the risks/safety issues will be minimised

All students (or groups) complete an evaluation sheet on each project proposal.OrStage a Science Convention where students prepare a display of the method for their investigation. Other students tour the displays and provide feedback/comments on others’ designs with post-it notes or similar. Use Two Stars and a Wish or 3-1 strategy to give structure to the feedback provided.Formative AssessmentStudents complete a planning sheet. |
| WS INS11/12-7* + select and use suitable forms of digital, visual, written and/or oral forms of communication
 | Importance of a controlStudents discuss what a control is in an experiment:* the standard or baseline to which treatments are compared
* when zero treatment is applied e.g. no fertiliser applied when testing the effect of different levels of fertiliser on plant growth

Investigate the different types of controls in experiments* [simple introduction](https://www.khanacademy.org/science/biology/intro-to-biology/science-of-biology/a/experiments-and-observations)
* find an example of Australian scientific research to present to the class, stating the aim of the research, identifying the independent, dependent and controlled variables and the control. Possible secondary sources:

Australia’s Science Channel, Cosmos, NewScientist, Popular Science, Discovery Science* investigating how cognitive biases are minimised by conducting double-blind randomised controlled trials, e.g. testing the hypothesis that people like the taste of bottled water more than tap water
 | * Students complete their investigation and report on their work. Their report may be presented as a written scientific report, a photo story, a short video or other multi-modal format.
* Students should also submit their learning journal documenting steps in the investigation.
* Students complete a reflection of their work:
	+ how did you arrive at your idea?
	+ what did you find difficult?
	+ what did you enjoy?
	+ did you discuss your ideas with others at any stage in the investigation?
	+ what improvements would you make?
 |
| Students:* evaluate how observation is limited by the observational tools available, including but not limited to:
	+ observing the Universe
	+ digital versus analogue technologies

WS INS11/12-3* + select and extract information from a wide range of reliable secondary sources and acknowledge them using an accepted referencing style

WS INS11/12-4* + select qualitative and quantitative data and information and represent them using a range of formats, digital technologies and appropriate media

WS INS11/12-7* + select and use suitable forms of digital, visual, written and/or oral forms of communication
 | Observations of the Universe – then, now and in the future[Telescopes](https://www.nasa.gov/centers/jpl/education/telescopes-20100405.html)* trace the history of our understanding of the Universe from the ancient Greeks, Aristarchus, Plato, Aristotle, Ptolemy, Copernicus, Brahe, Kepler, Galileo, Newton, Einstein, Friedmann, Hubble to present
* describe how each scientist made observations
* evaluate how observation, in each case, was [limited by the observational tools](http://www.atnf.csiro.au/outreach/education/senior/cosmicengine/historytop.html) available
* describe some of the instruments that are currently used to observe the Universe
* draw a timeline showing the development in our understanding of the universe
* predict how we might observe the Universe in the future and describe the technologies that will be required
* create a multimodal presentation that documents some of the observations made from space or of space

Digital vs Analogue* list examples of digital and analogue instruments
* explain why we need accuracy and reliability in all instruments used
* present points for and against the use of digital or analogue instruments to measure data such as temperature, current, mass, speed, sound

e.g. analogue - readings are often in whole numbers, human error in reading, parallax and approximation errors, training may be needed to read it accuratelydigital – readings to numerous decimal places, no observation errors such as parallax or approximation errors in taking readingsAustralia telescope national facility[International space station](https://www.nasa.gov/mission_pages/station/research/experiments_category.html)* investigate the [use of drones in collecting data](http://education.australiascience.tv/drones/) (login required)
 | Formative Assessment* Students show at least one form of authentic work, such as note-taking, highlighted readings, bibliography or review of science article based on secondary sources used.
* Students construct a timeline that shows the development of analogue and digital technologies, used for observing, over time.
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Ideas for related depth studies

* [Science in Practice](https://www.qcaa.qld.edu.au/downloads/senior/snr_science_prac_15_sas_syll.pdf)
* [Australian Nuclear Science & Technology Organisation](http://www.ansto.gov.au/)
* Given written or YouTube instructions, make a 3D hologram projector using your smartphone and investigate the properties of light

Reflection and evaluation

| Questions | Answers |
| --- | --- |
| What worked well? |       |
| What needed improving? |       |
| New resources and ideas? |       |
| Registration | Date commenced:      Date completed:       |