 Module 7 - Fact or fallacy

Year 12 Investigating Science

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Duration: 8 - 10 weeks

Description of unit

The scientific process is the most powerful tool available for generating knowledge about the world. It uses evidence and measurement to find truth and highlight misinterpretations and misrepresentations. Science as a human endeavour is subject to human failings, which can contribute to fallacies, misinterpretations and, on occasion, fraud. For this reason, scientific processes attempt to compensate for human failings by questioning evidence, re-testing ideas, replicating results and engaging with peer review to evaluate research.

Students investigate claims through conducting practical and secondary-sourced investigations and evaluate these based on scientific evidence. They explore examples of scientific claims made in the media and investigate the benefits of peer review.

In this module, students focus on selecting, processing, analysing and evaluating primary and secondary data and information sources. Students communicate scientific understanding and information about factual or fallacious claims. Students should be provided with opportunities to engage with all Working Scientifically skills throughout the course.

Focus questions

* How can a claim be tested?
* What factors can affect the way data can be interpreted, analysed and understood?
* What type of evidence is needed to draw valid conclusions?
* How does the reporting of science influence the general public’s understanding of the subject?
* Can the scientific community and process of peer review find “the truth”?

Working scientifically

A student:

* develops and evaluates questions and hypotheses for scientific investigation INS11/12-1
* selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media INS11/12-4
* analyses and evaluates primary and secondary data and information INS11/12-5
* solves scientific problems using primary and secondary data, critical thinking skills and scientific processes INS11/12-6
* communicates scientific understanding using suitable language and terminology for a specific audience or purpose INS11/12-7
* uses evidence-based analysis in a scientific investigation to support or refute a hypothesis INS12-14

Related Life Skills outcomes: SCLS6-4, SCLS6-5, SCLS6-6, SCLS6-7, SCLS6-13

While all Working Scientifically outcomes mandated for Investigating Science Module 7 are listed above, teachers may embed the outcomes and corresponding skill descriptors students throughout the sample unit of work

Assessment

* Option 1 - The completion of the depth study across 3 terms
* Option 2 - A practical investigation
* Option 3 - Research task/depth study - interview a practising scientist

Inquiry question: How can a claim be tested?

| Outcomes/content | Teaching and learning | Evidence of learning |
| --- | --- | --- |
| * plan and conduct an investigation based on testing a claim, and consider:
	+ validity of the experimental design
	+ reliability of the data obtained
	+ accuracy of the procedure, including random and systematic error
* using examples, evaluate the impact that sample selection and sample sizes can have on the results of an investigation
* compare emotive advertising with evidence-based claims, including but not limited to:
	+ health claims on food packaging
	+ claims about the efficacy of a product
 | * Students work collaboratively to plan and conduct an investigation to test a claim. Planning stages may involve viewing *Mythbusters* episodes and discussions about appropriate claims to test such as sugar free soft drink and electrolyte restoring sports drinks. Aspects of the investigation to be included are the validity, reliability and accuracy of the claim being made by the manufacturer.
* Define validity as “the extent to which tests measure what is intended, and to which data, inferences and actions produced from tests and other processes are accurate”.
* Define reliability as “an extent to which repeated observations and/or measurements taken under identical circumstances will yield identical results”.
* Recall that random errors are caused by inherently unpredictable fluctuations in the readings of a measurement, apparatus or in the experimenter's interpretation of the instrumental reading. Random errors show up as different results for ostensibly the same repeated measurement. They can be estimated by comparing multiple measurements (reliability) and reduced by averaging multiple measurements (accuracy).
* Recall that systematic errors are predictable and typically constant or proportional to the true value. If the cause of the systematic error can be identified, then it usually can be eliminated.
* Identify a “sample” as a subset of the population selected. It is an unbiased selection, representative of the larger population. Studies that use samples are less-expensive, and study of the entire population is sometimes impossible. It is important to select samples carefully as to obtain a representative sample of the population and to study a large enough sample size as to confidently conclude or exclude association between two parameters.
* View Sampling resources.
	+ [Example 1:](https://www.youtube.com/watch?v=pTuj57uXWlk) https://www.youtube.com/watch?v=pTuj57uXWlk
	+ [Example 2:](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4938277/) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4938277/
	+ [Example 3:](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3271469/) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3271469/
* Students view the resources on emotive advertising and produce a mind map of brainstormed ideas where sample selection and sample size would have an influence on the results of the investigation. For example - selecting only one ethnicity to do a taste test on a new food product or selecting only a very small sample size to test a new high-performance vehicle.
* Distinguish between emotive advertising and evidence-based claims. Some emotive advertising resources.
	+ [Example 1:](https://blog.hubspot.com/marketing/emotions-in-advertising-examples) https://blog.hubspot.com/marketing/emotions-in-advertising-examples
	+ [Example 2:](https://www.fastcompany.com/1682625/the-myth-of-marketing-how-research-reaches-for-the-heart-but-only-connects-with-the-head) https://www.fastcompany.com/1682625/the-myth-of-marketing-how-research-reaches-for-the-heart-but-only-connects-with-the-head
* Discuss the idea that people rely on emotions, rather than information, to make brand decisions and that emotional responses to advertisements are more influential on a person’s intent to buy than the content of an advertisement alone. For example, Happy Meal Ad, Recall of Nurofen Specific pain range or Electrolyte replacement sports drinks.

Possible Depth Study/Assessment taskStudents complete a practical investigation to test the validity of a claim | * Investigation report - The following sections should be included in the planned report.
	+ Background Information
	+ Safety
	+ Aim
	+ Hypothesis
	+ Materials and Method (including variables, focussing on ensuring validity, reliability and accuracy)
	+ Results
	+ Conclusion
	+ Discussion
* Student notes on the definitions of validity, reliability, accuracy and random and systematic errors. Students are then able to apply these to a well-researched and developed scientific process. For example, the Pea experiments by Gregor Mendel.
* Mind map on influence of sample selection and mind map on influence of sample size.
* View a variety of advertisements - students bring an example of their own that they like. Complete a table showing:
	+ Company name
	+ What is the advertisement for?
	+ What information or facts does the ad have?
	+ What emotions do they provoke?
	+ Give examples of emotive language used

Examples include* the recent class action against Nurofen for its [misleading advertising](http://www.smh.com.au/business/consumer-affairs/nurofen-settles-35m-class-action-20170802-gxo5m6.html) and promotion of products in the [Nurofen Specific Pain Range](https://www.youtube.com/watch?v=lxAaIrX_TLU).
* Electrolyte replacing sports drinks like Gatorade and Powerade are very high in sugar and [mislead the public](http://www.ausfoodnews.com.au/2014/10/08/choice-opposes-sports-drink-health-claims-as-misleading-consumers.html) into believing they are a healthier choice than water.
 |

Inquiry question: What factors can affect the way data can be interpreted, analysed and understood?

| Outcomes/content | Teaching and learning | Evidence of learning |
| --- | --- | --- |
| * using examples, justify the use of placebos, double-blind trials and control groups in order to draw valid conclusions
* evaluate the impact of societal and economic influences on the collection and interpretation of data, including but not limited to:
	+ predicting variations in climate
	+ suggesting remedies for health conditions
	+ manipulating statistical data
 | * Define a placebo as a medicine or procedure prescribed for the psychological benefit to the patient rather than for any physiological effect.
* Discuss the concept of a double-blind trial whereby an experiment or clinical trial is conducted where neither the subjects nor the researchers know which subjects are receiving the active medication, treatment, etc.
* Define a control group as the group in an experiment or study that does not receive treatment by the researchers and is then used as a benchmark to compare against the test subjects.
* [View the video clip](https://www.youtube.com/watch?v=GMqrOdCx4Yg) and take notes on the “Placebo Effect, Control Groups and the Double-Blind experiment” video, then hold a group discussion to justify the use of each to draw valid conclusions. Brainstorm examples of each via internet research.
* Identify a societal influence as one where a person's emotions, opinions, or behaviours are affected by others. Social Influences are often observed in conformity, socialization, peer pressure, obedience, leadership, persuasion, sales, and marketing.
* Identify an economic influence as once where a monetary gain is involved. Economic influences are the effect that an event, policy change, or market trend will have on economic factors such as interest rates, consumer confidence, stock market activity, or unemployment.
* Discuss the questions embedded in the [Activity on “What Is the Future of Earth's Climate?”](https://www.nationalgeographic.org/lesson/what-future-earths-climate/) and evaluate the impact of societal and economic influences on the collection and interpretation of data on predicting variations in climate.
 | * Student notes on definitions of placebo, double-blind trial and control group.
* Student notes on the Video “Placebo Effect, Control Groups and the Double-Blind experiment”.
* Discussion points on justification of the use of placebos, double-blind trials and control groups to draw valid conclusions.
 |

Inquiry question: What type of evidence is needed to draw valid conclusions?

| Outcomes/content | Teaching and learning | Evidence of learning |
| --- | --- | --- |
| * evaluate how evidence of a correlation can be misinterpreted as causation, including but not limited to:
	+ the Hawthorne effect
	+ 1991 study that linked hormone replacement therapy to coronary heart disease
	+ the Mozart Effect on child development
 | * Define Correlation and Causation
* Teachers and Students work together to model the analysis of the data from the economist article relating to correlation with popular media making a causation link. [Ice Cream Consumption vs PISA scores](https://www.economist.com/blogs/graphicdetail/2016/04/daily-chart)
* Students read summaries of articles and phenomena to investigate the evidence of correlation and causation. Students then analyse the effect of this assumption of causation and the effect it has had on society and create a summary of where correlation could be misinterpreted as causation. Students should use data from these articles and at least one other relevant articles provided to them:
	+ [Hawthorne effect - background and summary](http://www.statisticshowto.com/experimental-design/hawthorne-effect/)
	+ 1991 study that linked hormone replacement to coronary heart disease - [Article 1](https://academic.oup.com/ije/article-lookup/doi/10.1093/ije/dyh192) - [Article 2](http://hyper.ahajournals.org/content/hypertensionaha/44/6/789.full.pdf) - [Article 3](https://en.m.wikipedia.org/wiki/Women%27s_Health_Initiative). Note: It has been confirmed that the original study: Stampfer MJ, Colditz GA. Estrogen replacement therapy and coronary heart disease: a quantitative assessment of the epidemiologic evidence is not required, some future studies debating that causation are linked above.
	+ [The Mozart effect - background and summary](https://www.scientificamerican.com/article/fact-or-fiction-babies-ex/)
* Students create a graph plotting two unrelated sets of quantitative data that have correlation. Students then create a popular media article explaining, falsely, how this is causation that one causes the other. Other students in the class evaluate the types of evidence that would be required to show causation using their learning from the previous Inquiry question.
 | Student evaluations of articles that summarise their understanding of correlation and causation using a table showing:* Article Name
* Areas of article that showed correlation
* Areas of article that showed causation
* Where was the misinterpretation occurring?

Article produced by students and then peer evaluated. Peer evaluations are also assessed. |

Inquiry question: How does the reporting of science influence the general public’s understanding of the subject?

| Outcomes/content | Teaching and learning | Evidence of learning |
| --- | --- | --- |
| * examine a contemporary scientific debate and how it is portrayed in the mainstream media, including but not limited to:
	+ accuracy of information
	+ validity of data
	+ reliability of information sources
* evaluate the use and interpretation of the terms theory, hypothesis, belief and law in relation to media reporting of scientific developments
 | * Define theory, hypothesis, belief and law in a scientific context.
* Choose from a contemporary issue such as: Climate change, GMO foods, plastics use, stem cell research, human cloning. Make a list of the issues and arguments portrayed, in at least 3 media articles (text, audio, video) with at least 2 different points of view, under the headings of accuracy, validity and reliability.
* Evaluate the scientific words used in the article as to the correct uses of the terms.
 | Student notes on the definitions of theory, hypothesis, belief and law. Students use defined terms as well as accuracy, validity and reliability to produce an analysis and evaluation of three media articles on the same contemporary issue.For each article they should include:* Article name
* Who produced it
* The viewpoint of the author
* The accuracy of its information
* The validity of data
* The reliability of its sources
* The correct use of metalanguage
* The incorrect or deceptive uses of metalanguage.
 |
| * compare the difference in reporting between a peer-reviewed journal article and a scientific article published in popular media
 | * Students are given a journal article and a popular media article to look at. Students then discuss ideas as a class to be summarised into a Venn diagram. Focus should be on the use of language and readability. For each of the articles, students look at the following:
	+ What is the process of publishing?
	+ What is the product?
	+ What are the features?
	+ Who is the target audience?
	+ What is the Tenor?
	+ What is the Mode?
 | Students create a Venn diagram listing similarities and differences between peer reviewed journal articles and scientific articles from popular media. |
| * analyse how conflicts of interest can result in scientific evidence being suppressed, misinterpreted or misrepresented and discuss measures to counteract such conflicts, including but not limited to:
	+ tobacco industry and lung cancer
	+ fossil fuel industry and climate change
	+ commercial industries researching products for market
	+ asbestos mining and lung cancer
 | * “Conflicts of Interest” role playing activity [placeholder link to Google Doc]. There are up to nine role categories in each of the four scenarios. Teacher chooses which set of roles (categories) from the six to nine available and assigns students, either individually or in small groups, one role to develop their perspective and position within the scenario. Class discussion could either be developed around a simple ‘tell my story’ narrative or a mock trial.

(For those familiar with “Host a Murder” games the gameplay mechanisms of accusing and concealing information could be employed.)* References to movies like *The Insider* (1999) and Midnight Oil’s *Blue Sky Mine* (1990) may assist contextualise the issues.
* *An Inconvenient Truth* (2007).
* Other lesser known movies *Merchants of Doubt* (2014), *Greedy Lying Bastards* (2012) and *Everything’s Cool* (2007).
 | Students formulate arguments from different perspectives and discuss/debate their position based on their role within the scenario. In the process, they defend their perspective and challenge the other roles perspective. A range of questions are developed to promote critical thinking around the underlying issues. |
| * describe the halo effect and, using examples, explain how the influence of positive perceptions can result in the rejection of valid alternative perspectives, including but not limited to:
	+ celebrities endorsing products or viewpoints
	+ popular brand companies making misleading advertising claims
 | * Describe the halo effect and where this may be seen in marketing. Examples include the cosmetic industry and pet food industry.
* “Who do you trust?” activity. Teacher may lead the discussion, ppt of photos of professionals, celebrities and personalities.
* What is the value of reputation?
* Does lending one's name (or putting your name) to a cause or product diminish the impact of scientific evidence?
* As an example, consider Dr Oz (U.S.) and his “magical” health benefit claims on TV, and assess the impact of celebrity endorsement on the advertising of products or issues.
* Examine articles and news story coverage on YouTube.
* Examine a range of advertising material (TV, print, radio) and identify pseudo-scientific language, use of celebrities or figures of authority, and misleading or incorrect information.
 | * Students define the halo effect and how it is used in the cosmetics industry.
* Students list people they trust and to what degree. They then analyse the list to identify common attributes that may exist.
* Students examine the concept of reputation through class discussion and outline their thoughts.
* Students critically analyse the articles and news stories and prepare a (written) response to these questions.
* Students could prepare a mock interview with a celebrity and produce a podcast/video documentary.
* Students identify components within advertising and promotional material which demonstrates misleading or incorrect information.
 |
| * using examples, analyse a pseudo-scientific claim and how scientific language and processes can be manipulated to sway public opinion, including but not limited to:
	+ astrology
	+ numerology
	+ iridology
 | * Investigate the use of [astrology](http://www.relativelyinteresting.com/astrology-and-horoscopes-debunked/) and [numerology](https://science.howstuffworks.com/science-vs-myth/extrasensory-perceptions/numerology3.htm) plus other pseudo-scientific claims as appropriate.
* Identify the scientific language and processes that have been used to give credence to the claims then analyse the credibility of these claims. Discuss the public opinion of those claims.
* Write a response to the idea “If someone argues using lots of scientific terms, would it convince you or raise some red flags?” Students should be sure to use specific examples of where this is the case.
 | * Students analyse their understanding of a pseudo-scientific claim and the public opinion of those claims due to the scientific language and processes used.
* Students response to the idea “If someone argues using lots of scientific terms, would it convince you or raise some red flags?”
 |

Inquiry Question: Can the scientific community and process of peer review find ‘the truth’?

| Outcomes/content | Teaching and learning | Evidence of learning |
| --- | --- | --- |
| * conduct an investigation using secondary sources to research a scientist who has falsified their scientific experimental results, and discuss the process used to uncover the fraudulent research
 | * Define “What is a secondary source” and identify where they can be found.
* Students conduct research to find and correctly reference 1 article related to a scientist who has falsified results, for example; William McBride, Anna Ashimastos, Bruce Murdoch.
* Collaborate with fellow students in a *speed dating* activity ([See how to do this here](https://ablconnect.harvard.edu/speed-dating-research)) where they use narrative to share the story of their fraudulent scientist
 | Summarise the secondary source in a table to address the following:* Name of scientist and date experimental results were released and debunked
* What was their false claim?
* How was the claim uncovered?
* Who in society was impacted negatively by the falsifying of this research? For example; cancer sufferers and so on.
 |
| * analyse the scientific debate surrounding “publication” and discuss the implications of scientists’ need to “publish or perish”
 | * Define what is a scientific publication
* Listen to episode or read the transcript of [“Publish AND Perish: Science and Medical Researchers under pressure”](https://upclose.unimelb.edu.au/episode/367-publish-and-perish-science-and-medical-researchers-under-pressure#transcription)
* Discuss why a practising scientist needs to publish their research and why if they do not, they might “perish”. Formulate an argument from different perspectives
* Students participate in a mock board room meeting with the key stakeholders in Scientific research. For example - a Chancellor or Dean of a University, a Government body or donor providing funds for research, a farmer/patient/pensioner, and so on, and a scientist in pursuit of knowledge and ‘truth’.

Possible Assessment task/depth study* Discover a practising Scientist who is regularly publishing Scientific research papers. Students can choose a Scientist from a field of their own interest. In pairs, students generate a set of questions and conduct an over the phone/email interview with that scientist. Students should consider the following:
* Phone/email etiquette and the need for a high level of professional communication
* Clear and well-structured questions that address the ideas of “Publish or Perish”, steps involved in publishing and the funding of scientific research
* The importance of over preparation. This is so the interview can go ‘off script’. For example, students may ask further probing questions, clarifying questions to check for understanding or change the questions completely based on the direction of the conversation.
 | * Produce a flow chart describing the steps required to publish a paper
* Produce a summary of each point of view from the board room meeting.
 |
| * evaluate the increasing volume of scientific papers being published and assess the feasibility of science to effectively manage, review, replicate and validate investigations, for example:
	+ Pons and Fleischmann's cold fusion announcement in 1989
	+ Alex Smolyanitsky’s falsified scientific paper using the pseudonyms Maggie Simpson and Edna Krabapple, accepted for publication in 2014
	+ Tom Spears’ nonsense journal submission accepted for publication in 2013
 | * View image of government funds spent on research and development
	+ [Example 1](https://theconversation.com/infographic-how-much-does-australia-spend-on-science-and-research-61094)
* Conduct research about the number and types of articles for example; Medical, environmental, and so on, published each year. Present findings as an infographic
* Explain the importance of managing, reviewing, replicating and validating investigations.
* Evaluate a scientist's ability to frequently publish papers while maintaining the highest standard of quality and academic rigour. Use examples such as
	+ [Pons and Fleischmann](http://content.time.com/time/magazine/article/0%2C9171%2C151753%2C00.html)
	+ [Alex Smolyanitsky’s falsified scientific paper](https://www.sciencealert.com/two-scientific-journals-have-accepted-a-study-by-maggie-simpson-and-edna-krabappel)
 | Use an online software program such as Pikochart or Canva to design an infographic showing the statistics of the following:* The number of scientific articles published each year per person in Australia
* Comparison of Australian rates of publication vs other countries around the world
* Historical data showing publications rates over time
* The percentage of articles published specific to scientific research

Students evaluate the statement – there is a frequent need for scientists to publish papers. |
| * analyse the benefits of peer review in relation to the advancement of science
* discuss the impact of fake science journals on the public perception of science
 | * Starter activity: Complete the following game. 2 students sit back to back. Student A is given a picture and describes it to student B who attempts to draw it. Student A can view the drawing on 2 opportunities to give feedback to try and get it as close to the original picture as possible.
* View the [simple example of Austin’s Butterfly](https://www.youtube.com/watch?v=hqh1MRWZjms)
* Describe the [process of Peer Review](http://scijourno.com.au/portfolio-item/understanding-a-research-paper/). Explain how a paper undergoes the peer review process in Australia.
* Where do you go to find Peer Reviewed Scientific Journals? - for example “Google Scholar”
* Outline examples of how the Media influences the public perception of Science. Watch [Charlie Pickerings “The War on Science”](https://www.youtube.com/watch?v=xtWi9EwUAFc)
 | Write a comprehensive list of the benefits of peer review. Explain the need for scientists to work collaboratively and in teams to improve the quality of scientific work.To the flow chart completed previously on the scientific research process, add the additional steps required for peer review.Students compare and contrast a media article v a scientific paper. |

Reflection and evaluation:

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