# Sample Unit – Investigating Science – Year 12

***Sample for implementation for Year 11 from 2018***

***This unit is related to a Sample Assessment Schedule on the NESA website***

| **Unit title** | Module 7: Fact or Fallacy? | | **Duration** | 25 hours (additional 15 hours for Depth Studies) | |
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| **Unit description** | 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 in order 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.  **Working Scientifically**  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. | | | | |
| **Outcomes**  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   *(\*This outcome is not targeted in this module but will be used for formal assessment of one of the Depth Studies)* | | | | | |
| **Course requi**r**ements**   * Access to equipment suitable to test claims. * Various examples of emotive advertising and evidence-based claims, including but not limited to health claims on food packaging, claims about the efficacy of a product * Examples of:   + studies which have used either placebos, double-blind trials or control groups   + studies which demonstrate correlation being misinterpreted as causation including: the Hawthorne effect; 1991 study linking HRT to coronary heart disease; the Mozart effect on child development   + contemporary scientific debates which are portrayed in mainstream media   + how scientific information is suppressed, misinterpreted or misrepresented, including tobacco industry and lung cancer; fossil fuel industry and climate change; commercial industry researching products; asbestos mining and lung cancer   + pseudo-science claims including astrology; numerology; iridology * Extracts from peer-reviewed journal articles which can be compared with mainstream media articles on the same topic or issue. * Access to ICT to research examples of scientists who have falsified their research. | | | | **Formal Depth Study Assessment**  **Testing Claims**  Outcomes to be assessed: INS11/12-1, INS11/12-4, INS11/12-5, INS11/12-6, INS11/12-7, INS12-14  **Nature of task:**  Students investigate the claims made by products from one of the following industries   * Cosmetics * Food * Pharmaceuticals. | |
| **Topics**   1. Testing Claims 2. Impacts on Investigations 3. Evidence-based Analysis 4. Reading Between the Lines 5. Science as Self-correcting – the Issues | | **Inquiry questions**   1. How can a claim be tested? 2. What factors can affect the way data can be interpreted, analysed and understood? 3. What type of evidence is needed to draw valid conclusions? 4. How does the reporting of science influence the general public’s understanding of the subject? 5. Can the scientific community and the process of peer review find ‘the truth’? | | | |
| **Working Scientifically Skills**  **Questioning and Predicting – INS11/12-1**  A student develops and evaluates questions and hypotheses for scientific investigation  Students:   * develop and evaluate inquiry questions and hypotheses to identify a concept that can be investigated scientifically, involving primary and secondary data (ACSCH001, ACSCH061, ACSCH096)  Processing Data and Information – INS11/12-4 A student selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media  Students:   * select qualitative and quantitative data and information and represent them using a range of formats, digital technologies and appropriate media (ACSCH004, ACSCH007, ACSCH064, ACSCH101) * apply quantitative processes where appropriate * evaluate and improve the quality of data  Analysing Data and Information – INS11/12-5 A student analyses and evaluates primary and secondary data and information  Students:   * derive trends, patterns and relationships in data and information * assess error, uncertainty and limitations in data (ACSCH004, ACSCH005, ACSCH033, ACSCH099) * assess the relevance, accuracy, validity and reliability of primary and secondary data and suggest improvements to investigations (ACSCH005)  Problem Solving – INS11/12-6 A student solves scientific problems using primary and secondary data, critical thinking skills and scientific processes  Students:   * use modelling (including mathematical examples) to explain phenomena, make predictions and solve problems using evidence from primary and secondary sources (ACSCH006, ACSCH010) * use scientific evidence and critical thinking skills to solve problems  Communicating – INS11/12-7 A student communicates scientific understanding using suitable language and terminology for a specific audience or purpose  Students:   * select and use suitable forms of digital, visual, written and/or oral forms of communication * select and apply appropriate scientific notations, nomenclature and scientific language to communicate in a variety of contexts (ACSCH008, ACSCH036, ACSCH067, ACSCH102) * construct evidence-based arguments and engage in peer feedback to evaluate an argument or conclusion (ACSCH034, ACSCH036) | | | | | **Depth study (15 hours)**  Over the course of the unit students will be expected to select, process, analyse and evaluate primary and secondary data and information sources.  Students communicate scientific understanding and information about factual or fallacious claims. Students are to be provided with opportunities to engage with all the Working Scientifically skills throughout the course. |

| **Topic: Testing Claims** | | |
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| **Inquiry question:** How can a claim be tested? | | |
| **Content** | **Teaching, learning and assessment** | **Differentiation** |
| **Students:**   * 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 | * Conduct an experiment to test a claim * Research this claim and perform an experiment to test the claim. * Students produce a report on their findings. This will be presented to the class who can act as the Royal Society and evaluate the experiment (peer review). * Students provide feedback to the experimenter by commenting on:   + validity of the experimental design   + reliability of the data obtained and   + accuracy of the procedure, including random or systematic error | **Structured**  Provide students with a range of experiments that can be done with teacher guidance.  Provide a scaffold for students to use when addressing validity, reliability and accuracy |
|  | **Depth Study** (3 hours)  Students re-examine/reinforce the targeted outcomes of this unit through the Depth Study to communicate scientific understanding and information about factual or fallacious claims   * Students conduct research on a product selected from one of the following industries that has made claims about a product’s efficacy:   + Cosmetics   + Food   + Pharmaceuticals * Students research the types of claims made about the product and conduct initial research into the methods that have led to or could be used to test these claims * Students gather evidence about the availability of research data that supports the claim * Students maintain a media file of articles which report scientific research in popular media. For each article students:   + make a brief description of the research   + comment on the use of scientific terminology   + evaluate the validity of the data   + evaluate the reliability of the information source | **Extension**  Students liaise with manufacturers to inquire about statistical data publically available that supports claims made in relation to their products |
| **Students:**   * using examples, evaluate the impact that sample selection and sample sizes can have on the results of an investigation | * Students design a simple survey which can be conducted on a small sample size, for example ‘Who likes black jelly beans?’ * Students identify questions in the survey to be associated with another variable to show the impact of sample selection, for example gender or age * Students may use Survey Monkey or other software which can collate data electronically * From this small sample size students draw a conclusion from the data * Students discuss the limitations of the data and the affect this has on the reliability of claims which can be made from the sample of respondents that were selected * Students repeat the survey on a much larger sample size, eg the whole year group * Students reassess the reliability of the original conclusion * Students discuss and note with students the importance of sample selection and size when designing and conducting experiments * Students conduct research into experiments that have been reported in main-stream media which have a small sample size and unreliable sample selection, for example Manuka honey study, lemon detox study * Students evaluate each study and how the results may have been compromised | **Structured**  Provide students with specific experiments to research and scaffold the evaluation of these experiments |
| **Students:**   * 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 display a number of emotive advertisements. Include examples which contain: * health claims on food packaging * product efficacy claims * environmental claims * Students conduct research to find advertisements with evidence-based claims * Students must include advertisements about: * health claims on food packaging * product efficacy claims and * environmental claims * As a class, students make a comparison between emotive and evidence-based claims * Summarise information using a Venn diagram | **Structured**  Demonstrate methods for substantiating evidence based claims |
|  | **Depth study continued** (2 hours)   * Students research the analytic methods used by industry and those that can be used in class to test the claims made by the company about its product. * Students are too design an appropriate method to test the claims, either by executing a primary investigation or by reporting on secondary-sourced data |  |

| **Topic: Impacts on Investigations** | | |
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| **Inquiry question:** What factors can affect the way data can be interpreted, analysed and understood? | | |
| **Content** | **Teaching, learning and assessment** | **Differentiation** |
| **Students:**   * using examples, justify the use of placebos, double-blind trials and control groups in order to draw valid conclusions | * Demonstrate the use of placebos and [double-blind trials](http://www.centreofthecell.org/wp-content/uploads/Double_Blind_Trials.pdf) in medicine to undertake the following activity: * taste-tests of clear lemonade and lemonade which has been dyed red are used to demonstrate the placebo effect * a scenario about testing of sunscreen is used to demonstrate double-blind trials * Divide the class into groups and each group research at least two examples of the use of placebos, double-blind trials or control groups. Each group reports back to the class on the studies they investigate which includes:   + purpose of the investigation   + outline of the experimental design   + description of how the placebo, double-blind trial or control group resulted in a valid conclusion being drawn * As a class, summarise each group’s findings in a table with the following headings:   + outline of study   + description of results   + justification of use of placebo   + double-blind trial   + control group   **Assessment for Learning:**  Provide students with a description of a study which was designed to gather valid and reliable data to produce an evidence based conclusion and:   * evaluate the study, making note of the use of:   + evidence-based claims   + sample size   + sample selection   + placebo, double-blind trial or control group * submit for feedback and/or peer review | **Structured**  Provide students with examples of the use of placebos, double-blind trials or control groups and a table to summarise the information |
| **Students:**   * 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 | * Provide students with examples of case studies which demonstrate the societal and economic influence on the collection and interpretation of data. Ensure students are provided with examples which relate to:   + predicting variations in climate   + suggesting remedies for health   + manipulation of statistical data * Examples of case studies and supporting information can be found at: * [Impact case studies CSIRO](http://www.csiro.au/en/About/Our-impact/Our-impact-in-action/Latest-impact-case-studies) * [Preventing and treating ill health](http://www.aihw.gov.au/australias-health/2014/preventing-ill-health/#t2) * [Unorthodox techniques for the treatment of allergy](https://www.allergy.org.au/health-professionals/papers/unorthodox-techniques-for-diagnosis-and-treatment) * Students work in groups to describe how society and/or the economy has influenced the collection and interpretation of data. For each case study students complete a ‘Circle of Viewpoints Thinking Routine’: * ‘I am thinking of (the topic) from the viewpoint of (choose a representative from society or the economy).’ * ‘I think (describe the topic from the viewpoint chosen)’ * ‘A question I have from this viewpoint is …’ * Reflection: * What new ideas do you have about the topic that you didn’t have before? * What new questions do you have? * Students record their responses and the shared responses from the class   **Assessment for Learning:**  Students:   * evaluate the impact on society and the economy of the collection and interpretation of data using examples to support their responses * develop success criteria which they use to reflect on their work and then teacher provides feedback | **Extension**  Students collect data and represent it in an attempt to persuade a target audience that a fictitious claim is plausible.  **Structured**  Provide students who require adjustments an appropriate scaffold to complete the question. |
|  | **Depth study continued** (2 hours)   * Students collect and collate the data from the primary investigation or from the secondary-sourced investigation * Students investigate, in depth, the ways in which the collected data can be interpreted, analysed and understood |  |

| **Topic: Evidence-based Analysis** | | |
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| **Inquiry question:** What type of evidence is needed to draw valid conclusions? | | |
| **Content** | **Teaching, learning and assessment** | **Differentiation** |
| **Students:**   * 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 | * Show students spurious examples of [correlation showing causation](http://www.tylervigen.com/spurious-correlations) * Students describe and note what the graphs and statistics show and have students think, pair, share conclusions based on this data. Use the thinking routine: *This is what I see, this is what I think* * Peers can challenge the conclusions drawn by asking, ‘What makes you say that?’ * Students use the [Australian Bureau of Statistics](http://www.abs.gov.au/websitedbs/a3121120.nsf/home/statistical+language+-+correlation+and+causation) site to describe the difference between correlation and causation * Divide students into groups and give each group an example of how correlation has been misrepresented as causation. Include:   + the Hawthorne effect   + the 1991 study that linked hormone replacement therapy to coronary heart disease   + the Mozart effect on child development   + vaccination and autism   + children who sleep with a nightlight develop myopia * Students summarise the information into a table using the headings:   + Description of study   + Outline of conclusions made   + Description of how this shows correlation can be misinterpreted as causation. * Each group shares their summary with the class |  |
|  | **Depth Study continued** (3 hours)   * Students investigate the type of evidence that supports or refutes the claims made by each of the three companies in order to draw valid conclusions |  |

| **Topic: Reading Between the Lines** | | |
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| **Inquiry question:** How does the reporting of science influence the general public’s understanding of the subject? | | |
| **Content** | **Teaching, learning and assessment** | **Differentiation** |
| **Students:**   * examine a contemporary scientific debate and how it is portrayed in the mainstream media, including but not limited to: * validity of data * reliability of information sources * accuracy of information * evaluate the use and interpretation of the terms ‘theory’, ‘hypothesis’, ‘belief’ and ‘law’ in relation to media reporting of scientific developments | * As a class, brainstorm and note examples of contemporary scientific debates. * Students find examples of these debates in mainstream media and share with the class. * Discuss and note: * validity of the data * reliability of the information sources * accuracy of the information * possible bias of the publisher * comparisons with other sources which have reported the same research * use of scientific language * Using the examples above, students identify where the terms, ‘theory’, ‘hypothesis’, ‘belief’ and ‘law’ have been used in news articles. Sites such as the Sydney Morning Herald and ABC have science and technology sections which may be of use. * Students evaluate the use of these terms by making a judgement on the accuracy of the use of the terms and the meaning that the terms give to the articles.   **Assessment for Learning:** Students use one of the articles and rewrite this using the terms correctly. Use a [Gallery Walk](https://www.facinghistory.org/resource-library/teaching-strategies/gallery-walk) for students to evaluate their peers’ work. |  |
| **Students:**   * compare the difference in reporting between a peer-reviewed journal article and a scientific article published in popular media | * Discuss and note the features of a peer-reviewed journal article using an example to guide the discussion. Students describe the process of peer-review * Students source a peer-reviewed article and a popular media article covering the same research * Students analyse the journal article by reading through and identifying sections and terms they understand * Read through a second time, identifying sections and terms they don’t understand. * Research these sections for understanding * Summarise the main points of the research:   + Heading   + Author/s   + Problem which was investigated   + Methodology   + Findings   + Conclusions. * Students compare this to the popular media article. Identify similarities and differences. | **Structured**  Provide students with extracts from a peer-reviewed article, ensuring that the content is accessible for students. |
|  | **Depth Study continued** (3 hours)   * Students investigate, in depth, how reporting of each product in the media, advertising and/or general news stories influences the general public’s acceptance of each claim |  |
| **Students:**   * 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 | * Provide students with a scenario where they are a company board member who has just been provided with unfavourable statistical information about a lucrative company product. This could be fanciful information, eg eating a particular brand of chocolate has been linked to the ‘zombie virus’ or linked to some other real situation * To protect the company profits and their bonuses, students are told they can: * suppress * misinterpret * misrepresent this information * Students develop a short dialogue from the perspective of a person involved in the scenario, eg the company director, employee, researcher, consumer * The dialogue explains how the decision of the company has affected them * As a class, discuss and note how each option may be represented to the public and the implications of each decision for the company and the public. * Students identify examples of how conflicts of interest have influenced the reporting of scientific information * In groups, students are provided with a case study of how a conflict of interest has led to the suppression, misinterpretation or misrepresentation of scientific information. * Use the student-identified examples and include case studies related to the following:   + tobacco industry and lung cancer   + fossil fuel industry and climate change   + commercial industries researching products for market   + asbestos mining and lung cancer * Students analyse the example provided and summarise the case study in a table with the following headings and using data where necessary:   + Identify Company/Industry   + Describe the Scientific Evidence   + Describe the Industry/Company Response   + Outline Impact on Stakeholders   + Discuss Measures to Counteract the Conflict of Interest * Students share their summary with the class   **Assessment as Learning:**  Students:   * analyse how conflicts of interest can result in scientific evidence being suppressed, misinterpreted or misrepresented and discuss how measures were established to counteract this conflict of interest using an example to support their response * discuss and develop a marking criteria for the question, prepare a response, provide feedback on their response   Students should focus on: what they have done well; what they need to improve on; strategies they can implement to improve  *(Self-reflection is the emphasis for this assessment strategy)* |  |
| **Students:**   * 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 | * Students find examples of engaging advertisements for mundane products. * As students share their examples with the class, note the similarities between the advertisements, particularly if scientific or data-based claims are being used by celebrities * Discuss and note the halo effectand how it has been used in advertising to influence perceptions which can result in the rejection of valid alternative perspectives * Students find and note examples of the halo effect involving celebrities endorsing products and popular brand companies making misleading advertising claims * Students develop their own advertisement for a product and present to the class * Students provide feedback to the presenters by indicating if they would purchase the product and what factors influenced student’s decisions? |  |
| **Students:**   * using examples, analyse a pseudoscientific claim and how scientific language and processes can be manipulated to sway public opinion, including but not limited to: * astrology * numerology * iridology | * Students examine the following as pseudoscience:   + astrology   + numerology   + iridology   + phrenology   + feng shui   + radionics   + auto dynamics * Students outline the pseudoscience claim and explain how this claim has been debunked * Students identify scientific language that is used in secondary sources to promote the pseudoscience * Discuss and note as a class how scientific language is used to sway public opinion | **Structured**  Provide students with the sources and have them summarise content. Students highlight sections which contain scientific language. |
| **Topic: Science as self-correcting – the issues** | | |
| **Inquiry question:** Can the scientific community and process of peer review find ‘the truth’? | | |
| **Content** | **Teaching, learning and assessment** | **Differentiation** |
| **Students:**   * 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 | * Students use secondary sources to research a scientist who has falsified their results. Students summarise their findings on a ‘Most Wanted’ poster and include information describing the experimental results and the process used to reveal the fraudulent research. Present to the class and develop a ‘Most Wanted’ list of scientists who have falsified their experimental results * Discuss and note the processes used to uncover the fraudulent research. | **Structured**  Provide students with a case study of a scientist who has falsified their research. Students then use this to guide independent research. |
| **Students:**   * analyse the scientific debate surrounding ‘publication’ and discuss the implications of scientists’ need to ‘publish or perish’ | * Provide students with an article which addresses the issue of publish or perish. * Examples can be found at: * [Science and Medical researchers under pressure](http://www.australasianscience.com.au/article/issue-may-2016/publish-and-perish-science-and-medical-researchers-under-pressure.html) * [The pressure to fudge medical research findings](http://www.abc.net.au/news/2013-10-25/scott-selling-science/5043620) * [Publish or perish: Where are we heading?](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3999612/) * [Publish or perish: Peer review and the corruption of science](https://www.theguardian.com/science/2011/sep/05/publish-perish-peer-review-science) * Discuss and note the scientific debate surrounding publication and the implications of scientists’ need to publish their research. |  |
| **Students:**   * + 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 * 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 | * Students play ‘Who Am I?’: provide students with the surnames of researchers who have published nonsense research:   + Pons and Fleischmann   + Smolyanitsky   + Spears * Students investigate these researchers and find out how they are linked, ie they look at the ability of the scientific community to manage, review, replicate and validate investigations * Provide students with articles which address the issue of the volume of scientific articles: * [Is the peer review process for scientific papers broken?](http://time.com/81388/is-the-peer-review-process-for-scientific-papers-broken/) * [How science goes wrong](http://www.economist.com/news/leaders/21588069-scientific-research-has-changed-world-now-it-needs-change-itself-how-science-goes-wrong) * Students propose reasons why scientific research can be, at times, tenuous. * Discuss and note the increasing volume of scientific papers being published. * Students suggest what impact this has on the validity of scientific research. * Students assess the ability of the scientific community to effectively:   + manage   + review   + replicate and validate investigations * Discuss options available to the scientific community to address these issues * Students analyse the benefits of the peer-review process for the advancement of science * Students suggest and note the impact of fake science on the public perception of science   **Assessment for Learning:** Students prepare a response to the following:   * Analyse the impact on the public perception of science in light of the volume of scientific research presented to the scientific community for review. Use specific examples to support your response. * Students submit their response for feedback |  |
|  | **Depth study continued** (2 hours)   * Students research and report on the process of peer review using a scientific article from a recognised and reliable scientific journal * Students present their report and participate in a class peer-review process * In the report that analyses the claims of the manufacturer, students must consider and comment on the following: * validity and reliability of the investigative techniques * if an experiment was performed the possible bias of the researcher/s * sample size and selection * reliability of the data presented |  |

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| **Resources** |
| Double-blind trials: <http://www.centreofthecell.org/wp-content/uploads/Double_Blind_Trials.pdf>  Impact case studies CSIRO: <http://www.csiro.au/en/About/Our-impact/Our-impact-in-action/Latest-impact-case-studies>  Preventing and treating ill health: <http://www.aihw.gov.au/australias-health/2014/preventing-ill-health/#t2>  Unorthodox techniques for treatment of allergy: <https://www.allergy.org.au/health-professionals/papers/unorthodox-techniques-for-diagnosis-and-treatment>  Correlation causing causation: <http://www.tylervigen.com/spurious-correlations>  Australian Bureau of Statistics: <http://www.abs.gov.au/websitedbs/a3121120.nsf/home/statistical+language+-+correlation+and+causation>  Gallery Walk: <https://www.facinghistory.org/resource-library/teaching-strategies/gallery-walk>  Science and medical researchers under pressure: <http://www.australasianscience.com.au/article/issue-may-2016/publish-and-perish-science-and-medical-researchers-under-pressure.html>  The pressure to fudge medical research findings: <http://www.abc.net.au/news/2013-10-25/scott-selling-science/5043620>  Publish or perish: Where are we heading?: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3999612/>  Publish or perish: Peer review and the corruption of science: <https://www.theguardian.com/science/2011/sep/05/publish-perish-peer-review-science>  Is the peer review process for scientific papers broken?: <http://time.com/81388/is-the-peer-review-process-for-scientific-papers-broken/>  How science goes wrong: <http://www.economist.com/news/leaders/21588069-scientific-research-has-changed-world-now-it-needs-change-itself-how-science-goes-wrong> |

**Resources, Reflection and Evaluation**

Teacher sign off………………………………… Date commenced……………………… Date completed…………………………….

Program evaluation and recommended amendments

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Recommended additional text/resources

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