

# 2019 HSC Science Extension

## Marking Guidelines

### Section 1

#### Question 1

Criteria	Marks
<ul style="list-style-type: none"> <li>Provides a comprehensive explanation of why the journal editor may be concerned about the quality and reporting of the research</li> <li>Puts forward a variety of relevant arguments</li> <li>Supports arguments with evidence in areas such as referencing techniques, literature review and research design</li> </ul>	5
<ul style="list-style-type: none"> <li>Provides a thorough explanation of why the journal editor may be concerned about the quality and reporting of the research</li> <li>Puts forward relevant arguments</li> <li>Supports arguments with evidence in areas such as referencing techniques, literature review and research design</li> </ul>	4
<ul style="list-style-type: none"> <li>Demonstrates a sound understanding of why the journal editor may be concerned about the quality and/or reporting of the research</li> <li>Puts forward relevant argument(s)</li> <li>Uses evidence in areas such as referencing techniques, literature review and research design to support the answer</li> </ul>	2–3
<ul style="list-style-type: none"> <li>Demonstrates an understanding of quality research</li> </ul>	1

#### **Sample answer:**

The student's research study is recent. However, the literature underpinning the study is more than 15 years old. Since data on plastic pollution is likely to change rapidly, more up-to-date references are required.

Smith (2003) is a blog which represents one person's opinion and has not undergone peer review, nor is it referenced in the text. In addition, four of the five references are from the same journal. If the journal has a particular bias or accepts papers from one country more than another, these references would not represent a good sample of known work in the subject area.

The formatting of the reference list is inconsistent and inaccurate. Titles of the papers should be included. The inaccuracy makes it difficult for readers to trace the sources of information. It also shows a lack of academic rigour and respect for the authors of the research studies.

The source for the statistics for the southern hemisphere was not provided. It will not only be difficult for readers to trace the source; it may also be considered plagiarism.

Finally, a study carried out within Sydney Harbour is unlikely to be representative of oceans in the southern hemisphere, especially since the author has already acknowledged "Accumulation of plastic pollution has been observed in closed bays ... surrounded by densely populated coastlines".

## Question 2 (a)

Criteria	Marks
<ul style="list-style-type: none"> <li>Provides a comprehensive explanation of how statistical analysis could be applied to support decision making in the scenario</li> <li>Clearly relates specific statistical tests to the characteristics of both data sets</li> <li>Clearly shows how a conclusion can be drawn from the results of the statistical analysis</li> </ul>	5
<ul style="list-style-type: none"> <li>Provides a thorough explanation of how statistical analysis could be applied to support decision making in the scenario</li> <li>Relates specific statistical tests to the characteristics of both data sets</li> </ul>	4
<ul style="list-style-type: none"> <li>Demonstrates a sound understanding of how statistical analysis could be applied to the scenario</li> <li>Shows some understanding of the characteristics of data set(s)</li> </ul>	2–3
<ul style="list-style-type: none"> <li>Demonstrates an understanding of how statistical analysis could be applied to the scenario</li> </ul>	1

### **Sample answer:**

The null hypothesis is that there is no difference between the toy dog and the robotic dog. Statistical tests need to be applied to determine if this is true. If there is less than a 5% chance that there is no statistically significant difference between the two groups ( $P < 0.05$ ), the null hypothesis can be rejected.

Different types of data require the use of different statistical tests. Table 1 contains two groups of continuous data with similar standard deviations. The means of the two groups can therefore be compared using the Student's t-test. A statistically significant difference indicates that one dog substitute should be recommended.

The data in Figure 1 are categorical. Because the data is in discrete categories and the null hypothesis expects there will be an equal number of interactions in each category, the Chi-squared test will determine whether the expected frequencies and observed frequencies are statistically different.

If both types of data show significant differences in favour of the same dog substitute, this supports the decision to use that dog substitute. Conflicting or non-significant results would suggest that there is not a meaningful difference. Therefore, no recommendation can be made based on this data.

## Question 2 (b)

Criteria	Marks
<ul style="list-style-type: none"> <li>• Demonstrates a thorough understanding of inductive reasoning</li> <li>• Clearly relates issues associated with the use of inductive reasoning to this scenario</li> <li>• Provides points for and/or against the use of inductive reasoning in making recommendations for other hospitals</li> </ul>	3
<ul style="list-style-type: none"> <li>• Demonstrates a sound understanding of inductive reasoning</li> <li>• Recognises issues associated with the use of inductive reasoning</li> <li>• Provides points for and/or against the use of inductive reasoning in making recommendations for other hospitals</li> </ul>	2
<ul style="list-style-type: none"> <li>• Demonstrates an understanding of inductive reasoning</li> </ul>	1

### **Sample answer:**

Induction is the forming of larger scale understandings from smaller scale data and results. Thus from an investigation of a specific case, the findings can be applied more widely. The advantage of this is that studies do not have to be replicated in every hospital. However, results from this study are specific to the population in the particular study group from this hospital. Therefore, other hospitals need to have similar resident populations in order to apply the results to the new situation.

If the original study does not have an appropriate sample size and valid study design, the recommendation for other hospitals may be invalid, as these errors will be transferred.

### Question 3

Criteria	Marks
<ul style="list-style-type: none"> <li>Provides an extensive analysis of the effects of bias on scientific thinking and research</li> <li>Integrates the three sources to support the analysis</li> <li>Demonstrates accurate interpretation and effective processing of relevant scientific data</li> </ul>	7
<ul style="list-style-type: none"> <li>Provides a thorough analysis of the effects of bias on scientific thinking and research</li> <li>Supports the analysis with the three sources</li> <li>Demonstrates accurate interpretation of relevant scientific data</li> </ul>	6
<ul style="list-style-type: none"> <li>Provides an analysis of the effects of bias on scientific thinking and research</li> <li>Uses sources to support the analysis</li> <li>Demonstrates comprehension of scientific data</li> </ul>	4–5
<ul style="list-style-type: none"> <li>Demonstrates a sound understanding of the effects of bias on scientific thinking and research</li> <li>Makes reference to the sources</li> </ul>	2–3
<ul style="list-style-type: none"> <li>Demonstrates an understanding of the effects of bias on scientific thinking and research</li> <li>Refers to at least one source</li> </ul>	1

**Sample answer:**

Science strives for objectivity.

Bias can limit the scope of science. For example, with confirmation bias researchers only see the results and relationships that they are seeking. Source 1 shows how supporters of the ‘bad air’ theory used confirmation bias in their evaluation of the mathematical model. This is an example of the theory-dependence of observations. This stifled the progress of the science around other possible causes as the supporters become more steadfast in their theory.

Vested interests can also bias the findings of scientific research and lead to skewed results. When research teams need to receive funding to operate, there can be a conscious or unconscious effort to reach the conclusions desired by the funding source. This is shown in Source 2’s graph, where berry industry funded research was more likely to find that the berry consumption lowered LDL cholesterol levels than independently funded research.

Globally, scientific researchers are influenced heavily by the need to ‘publish or perish’. This can bias the type of scientific research that is undertaken and/or published. As shown in Source 3, research findings that do not strongly support a hypothesis are less likely to be written up and published in journals. Therefore, scientists are less likely to pursue research they suspect will not produce strong results. Strong results are also more likely to be published in ‘top’ journals, meaning they are more likely to be widely read, skewing the direction of further research. Such publication bias can prevent researchers from drawing wider conclusions based on null results, limiting the development of scientific fields.

These examples show that confirmation bias around economic influences, and global patterns in academia, can influence the direction of scientific thinking, reporting, results and type of research undertaken. These biases negatively affect the objectivity of scientific thinking.

## Section 2, Part A

### Question 4

Criteria	Marks
<ul style="list-style-type: none"> <li>• Demonstrates an extensive understanding of the importance of context, audience and purpose when communicating research findings</li> <li>• Effectively compares the features of different modes of communication in science using the sources provided and the student research report</li> <li>• Provides an insightful analysis of methods used to communicate research findings</li> </ul>	7–8
<ul style="list-style-type: none"> <li>• Demonstrates a thorough understanding of the importance of context, audience and purpose when communicating research findings</li> <li>• Uses the sources provided and/or the student research report to explain the features of different modes of communication in science</li> <li>• Provides a thorough analysis of methods used to communicate research findings</li> </ul>	5–6
<ul style="list-style-type: none"> <li>• Demonstrates a sound understanding of the importance of context and/or audience and/or purpose when communicating research findings</li> <li>• Uses the source(s) provided and/or the student research report to describe the features of different modes of communication in science</li> </ul>	3–4
<ul style="list-style-type: none"> <li>• Demonstrates an understanding of methods used to communicate research findings</li> <li>• Uses the source(s) provided and/or the student research report to demonstrate features of communication in science</li> </ul>	1–2

**Sample answer:**

Communicating science is a central part of doing science. Scientists most often communicate their research findings to other scientists in their field, but also to members of the public who have varying levels of scientific literacy. Decisions on communication methods should be based on the intended audience, purpose, context and necessary level of detail.

Scientists communicate detailed findings of their research to other scientists with the purpose of convincing the reader that the research findings are valid and the experiments can be replicated, usually by publishing an article in a scientific journal after peer review. This format is standardised to allow for objective review and my research report was modelled on this format. I reported my methodology and analysis of results, showing how they related to my hypothesis. The report was aimed at an audience with a scientific background such as my teachers and so used appropriate scientific terminology, including statistical analysis and confidence intervals to show validity.

Because science impacts our daily lives in many ways, it is important that an understanding of scientific research is effectively communicated to broader sections of the community. Different formats are often used, such as the video and the infographic. The audiences may vary from those with an interest in science and why the Nobel Prize is awarded, to a general television audience seeking entertainment. The infographic summarises a large amount of research including a ‘Why does this matter’ paragraph so that a general audience can access big ideas in science. It uses scientific terminology and graphics that require some background in science. Digital infographics or academic posters may be used in other contexts such as scientific conferences to summarise results.

In the television video, the purpose is to deliver public health information, using visual effects. This successfully presents complex physiology to a lay audience in non-scientific language without discussing methodology or research validity. These visual formats may synthesise a large number of complex research findings from numerous journal articles and reports (like my own) into a coherent story for broader audiences. The audience, purpose and context determine the most suitable form of communication.

## Question 5

Criteria	Marks
<ul style="list-style-type: none"> <li>Provides a comprehensive explanation of the steps and considerations for developing an appropriate research question and hypothesis</li> <li>Shows clearly how the steps and considerations relate to the source</li> </ul>	7
<ul style="list-style-type: none"> <li>Provides a thorough explanation of the steps and considerations for developing an appropriate research question and hypothesis</li> <li>Relates the steps and considerations to the source</li> </ul>	6
<ul style="list-style-type: none"> <li>Explains steps and/or considerations for developing an appropriate research question and/or hypothesis</li> <li>Relates steps and/or considerations to the source</li> </ul>	4–5
<ul style="list-style-type: none"> <li>Describes steps and/or considerations for developing an appropriate research question and/or hypothesis</li> </ul>	2–3
<ul style="list-style-type: none"> <li>Demonstrates an understanding of the development of a research question or hypothesis</li> </ul>	1

### **Sample answer:**

A literature review is a key step in developing a research question and hypothesis. This would involve surveying a large range of scientific literature related to the topic, such as the chemistry of carbon dioxide gas capture, geology of Iceland and the properties of basalt. This is important to provide an overview of the scientific work previously done, and what may warrant further research. When considering an appropriate hypothesis, this step is also important as it allows the student to identify relationships worthy of investigation.

Another important step would be to seek advice from experts in specific related fields like geochemistry. This type of collaboration will ensure the student chooses a research question that is important to the field and realistic to investigate. In addition to the literature review, an expert can provide the student with a depth of understanding that may help focus the research question.

Also, the hypothesis developed from the research question needs to be falsifiable, meaning that it must be able to be tested and could be shown to be false. For example, 'the depth of basalt affects the rate of carbon capture' would be appropriate, as an experiment could demonstrate that there is no relationship.

Environmental impacts are important to consider. Investigating the research question and hypothesis should not negatively impact the local ecosystem where the carbon capture takes place. This is often a requirement of gaining research approval from local institutions and governments.

Finally, the student needs to make realistic considerations of the funding required to investigate their research question and hypothesis. Along with financial limitations, technological and time limits should be considered. Otherwise, the investigation will not be able to be performed.

## Section 2, Part B

### Question 6

Criteria	Marks
<ul style="list-style-type: none"> <li>• Demonstrates extensive knowledge and understanding of the development of scientific methodology</li> <li>• Makes an informed judgement concerning the methods used in science</li> <li>• Integrates evidence from both models and the student research project to support a range of arguments</li> <li>• Communicates ideas and information using appropriate scientific language</li> <li>• Presents a logical and coherent response</li> </ul>	13–15
<ul style="list-style-type: none"> <li>• Demonstrates thorough knowledge and understanding of the development of scientific methodology</li> <li>• Makes a judgement concerning the methods used in science based on criteria</li> <li>• Supports a range of arguments with evidence from both models and the student research project</li> <li>• Communicates ideas and information using scientific language</li> <li>• Presents a logical response</li> </ul>	10–12
<ul style="list-style-type: none"> <li>• Demonstrates developed knowledge and understanding of the development of scientific methodology</li> <li>• Uses evidence from model(s) and/or the student research project to support the answer</li> <li>• Presents a structured response using scientific language</li> </ul>	7–9
<ul style="list-style-type: none"> <li>• Demonstrates sound knowledge and understanding of the development of scientific methodology</li> <li>• Makes reference to model(s) and/or the student research project to support the answer</li> <li>• Uses some scientific language</li> </ul>	4–6
<ul style="list-style-type: none"> <li>• Demonstrates an understanding of the development of scientific methodology</li> <li>• May refer to model(s) and/or the student research project</li> </ul>	1–3

**Sample answer:**

Scientific method relies on making and testing predictions. While scientific method is applied differently in different scientific fields, the basic principle is the same now as it was in the 19th century. From Model 1, Mendel obtained empirical data from pea plant experiments, leading to the conclusion that characteristics are inherited.

The process in Model 2 also demonstrates the empirical nature of the scientific method. Researchers and citizen scientists worked together using a large amount of observational data and no testable hypothesis. For questions such as ‘are there different types of objects in the universe’ it is not possible to control all variables and only collect one type of data. However, once a pattern or trend appears, or a new object in space is found, then a hypothesis about its properties can be validly tested if specific patterns in the data can be found and used.

By comparing the Voorwerp to known astronomical objects, they were able to classify it as a new type of object. Therefore, even with the different processes in each of the models, each discovery is still founded on observational data evaluated within a scientific framework (empiricism), suggesting there is one method in science.

However, it can be argued that research questions can be solved in different ways, there being no one way of doing things. Recent digital technology has opened up the capacity to both generate and share large data sets that are difficult to analyse and require new ways of 'doing science'. As in model 2 large numbers of volunteer citizens can be recruited and trained to assist with repetitive analyses efficiently in terms of financial, computational and time limits. Contact and communication with volunteers is enhanced by the internet and social media. Although volunteers can introduce sources of operator error, technology enables scientists to work more efficiently without fundamentally changing the underlying scientific method. Other technologies such as GPS have become accessible to all for gathering data that was not previously available.

In my own investigation into the effect of altitude on a cyclist's sprint performance, I was able to gather data from pedal mounted power meters, GPS trackers and publicly available weather data sets. Because of the large volume of data I was dealing with, I used the statistical tools on a spreadsheet to analyse the data. However, when I analysed my data I measured the effect of one variable on another, keeping all other variables constant. In undertaking my project, I followed the steps that are common in models 1 and 2. i.e. I started with an idea, tested and analysed my data which led me to a conclusion which was reviewed by my peers and was published in my report. While my report did not use the assistance of citizen scientists, it did use modern technology to collect and analyse the data.

While the 2 models and my research project are mainly a linear sequence, science is often circular in nature, proposing new hypotheses that could be tested, so restarting the process. Often observations are the starting point, instead of an idea. Science can start anywhere along these sequences and continue, then loop back again.

While each research question in science demands a different approach or methodology, scientists are constrained by the requirements of producing valid, reliable evidence that confirms or denies a hypothesis. Thus, the statement is not true because there is a general scientific method which is varied according to the subject area under investigation, the question being tested and the technology available. There is one way of doing science and the two models and my methodology illustrate the same method with minor variations.

# 2019 HSC Science Extension Mapping Grid

## Section 1

Question	Marks	Content	Syllabus outcomes
1	5	Module 2: Developing the Question and Hypothesis Module 2: Scientific Research Proposal Module 4: Reporting Findings	SE-1, SE-3, SE-7
2 (a)	5	Module 3: Patterns and Trends Module 3: Statistics in Scientific Research	SE-4
2 (b)	3	Module 1: The Development of Modern Science Module 3: Patterns and Trends	SE-2, SE-5
3	7	Module 1: The Development of Modern Science Module 1: Influences on Current Scientific Thinking Module 3: Statistics in Scientific Research Module 3: Decisions from Data and Evidence	SE-2, SE-5

## Section 2, Part A

Question	Marks	Content	Syllabus outcomes
4	8	Module 4: Reporting Findings	SE-1, SE-7
5	7	Module 1: Influences on Current Scientific Thinking Module 2: Developing the Question and Hypothesis	SE-1, SE2, SE-3

## Section 2, Part B

Question	Marks	Content	Syllabus outcomes
6	15	Module 1: The Development of Modern Science Module 2: Developing the Question and Hypothesis Module 2: Methodology and Data Collection Module 4: Reporting Findings	SE-1, SE-2, SE-5, SE-6, SE-7