

EXPLORATION					
Band	The topic of the investigation is identified and research question is:	Background information provided for the investigation is:	Appropriateness of the methodology of the investigation.	Consideration of factors that may influence the relevance reliability and sufficiency of collected data.	Evidence of awareness of the significant safety, ethical or environmental issues
6	Relevant and fully focused.	Entirely appropriate and relevant and enhances the understanding of the context of the investigation.	Highly	Nearly all factors considered.	Full - all potential hazards identified and dealt with appropriately
4	Relevant but not fully focused.	Mainly appropriate and relevant and aids the understanding of the context of the investigation.	Mainly	Some factors considered.	Limited
2	Some relevance but not focused.	Superficial or of limited relevance and does not aid the understanding of the context of the investigation	Limited	Few factors considered.	Some
0	Standard not reached	Standard not reached	Standard not reached	Standard not reached	Standard not reached

### Student Checklist

Identification of the topic of investigation		
<input type="checkbox"/> Research Question or Aim clearly stated <input type="checkbox"/> RQ/Aim includes IV and DV (and scientific name of organism if relevant)	<i>If a hypothesis is required:</i> <input type="checkbox"/> It is quantitative <input type="checkbox"/> It may be in the form of Null and Alternative Hypothesis (if statistical test involved)	<input type="checkbox"/> Prediction is explained using <b>scientific theory</b> . <input type="checkbox"/> Sources are cited appropriately.
Background information		
<input type="checkbox"/> Background information provided is <b>relevant</b> . <input type="checkbox"/> Background information <b>explains</b> the <b>context</b> of the investigation clearly.	<input type="checkbox"/> Sources are cited appropriately (in-text references and reference list provided).	
Appropriateness of the methodology of the investigation.		
<input type="checkbox"/> Does plan to collect data <b>address RQ</b> ? <input type="checkbox"/> Annotated photo of equipment or experimental set-up <input type="checkbox"/> Method for recording results, including units and uncertainty of tools ( $\pm$ _ )	<input type="checkbox"/> <b>Min. 5 increments</b> over a suitable range for the IV (unless comparing populations) <input type="checkbox"/> Method clearly presented in step-wise format and can be repeated by others. <input type="checkbox"/> What statistical test(s) will be used? Why?	<input type="checkbox"/> Results table designed <u>before</u> investigation is planned <input type="checkbox"/> Full citation of published protocol, if used.
Consideration of factors that may influence the relevance, reliability and sufficiency of collected data.		
<input type="checkbox"/> IV correctly identified with <b>units/ range</b> <input type="checkbox"/> Method to manipulate IV, including specific details of <b>range and increments</b> <input type="checkbox"/> Explain how range of IV was selected	<input type="checkbox"/> DV correctly identified with <b>units</b> and <b>precision</b> <input type="checkbox"/> Sufficient <b>repeats</b> at each increment to ensure <b>reliability</b> and allow for stats.	<input type="checkbox"/> List all variables to be controlled and present them in table, for each variable: <ul style="list-style-type: none"> <li>○ How could it <b>impact</b> the results?</li> <li>○ Exactly <b>how</b> will it be <b>controlled</b>? (Value, w method for achieving that value)</li> </ul>
Evidence of awareness of the significant safety, ethical or environmental issues		
<input type="checkbox"/> Safety/ ethics/environmental concerns addressed, including <b>animal experimentation policy</b> .		

ANALYSIS				
Band	Raw data is:	Data processing	Impact of uncertainties	Interpretation of processed
6	Sufficient. Could support a detailed and valid conclusion.	Appropriate and sufficient accuracy enables a conclusion to the RQ to be drawn that is fully consistent with data.	Full and appropriate consideration.	Correct valid and detailed interpretation.
4	Relevant but incomplete. Could support a simple or partially valid conclusion.	Appropriate and sufficient. Could lead to a broadly valid conclusion but significant inaccuracies and inconsistencies in the processing.	Some consideration.	Broadly valid limited interpret
2	Insufficient to support a valid conclusion.	Basic, inaccurate or too insufficient to lead to a valid conclusion	Little consideration.	Incorrect or insufficient inval very incomplete
0	Standard not reached.	Standard not reached.	Standard not reached.	Standard not reached.

### Student Checklist

#### Recording Raw Data

- |  |   |
|--|---|
| <input type="checkbox"/> Raw data clearly distinguished from processed data (possibly separate table)                      | <input type="checkbox"/> Uncertainties correct ( $\pm$ __ )   |
| <input type="checkbox"/> Raw data collected is <b>sufficient</b> to support a <b>detailed</b> and <b>valid</b> conclusion. | <input type="checkbox"/> All data are recorded correctly and honestly                               |
| <input type="checkbox"/> Units of IV and DV present and correct  | <input type="checkbox"/> Decimal points consistent throughout                                       |
|  | <input type="checkbox"/> Decimal points consistent with precision of the measuring equipment        |
|  | <input type="checkbox"/> <b>Associated qualitative data</b> (observations) <b>MUST</b> be recorded. |

#### Processing Raw Data

- |  |   |
|--|---|
| <input type="checkbox"/> Calculations to determine DV carried out, if necessary                        | <input type="checkbox"/> Processed data (and decimal places) consistent with precision of recorded data |
| <input type="checkbox"/> Calculations or statistical tests appropriate to investigation and address RQ | <input type="checkbox"/> Graph titles self-explanatory and complete                                     |
| <input type="checkbox"/> Mathematics correctly applied   | <input type="checkbox"/> Appropriate choice of graph  |
| <input type="checkbox"/> Worked example calculations given   | <input type="checkbox"/> Axes labeled clearly, including metric/ SI units and uncertainties of values   |
| <input type="checkbox"/> Standard deviations included where appropriate, with appropriate DP.          | <input type="checkbox"/> Axes scaled appropriately  |
|  | <input type="checkbox"/> Error bars included, unless insignificant                                      |
|  | <input type="checkbox"/> Error bar source (e.g. standard deviation) stated and data are correct         |
|  | <input type="checkbox"/> Line or curve of best fit included and reflect (if appropriate).               |

#### Impact of Uncertainties

- Uncertainties adjusted to reflect any calculations carried out.
- Uncertainties/ errors included in tables and graphs.
- Uncertainties/ errors justified.

#### Interpretation of Processed Data

- Patterns and trends** in data stated, with **specific numerical reference** to the graph/ tables.
- Comparisons, if appropriate, are made.

EVALUATION				
	Conclusion (data)	Conclusion (theory)	Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are	Realistic and relevant suggestions for the improvement and extension of the investigation.
6	Described in detail and justified, entirely relevant to the RQ and fully supported by the data.	Justified through relevant comparison to the accepted scientific context.	Discussed and provide evidence of a clear understanding of the methodological issues involved in establishing the conclusion.	Are discussed.
4	Described, relevant to the research question and supported by the data.	Some relevant comparison to accepted scientific context.	Described and provide evidence of some awareness of the methodological issues involved in establishing the conclusion.	Some described.
2	Outlined but may not be relevant to the research question or may not be supported by the data.	Erroneous or superficially compared to the accepted scientific context.	Outlined but are restricted to an account of the practical or procedural issues faced.	Very few outlined.
0	Standard not reached.	Standard not reached.	Standard not reached.	Standard not reached.

### Conclusion (data)

- Data related to RQ and hypothesis – to what extent do they agree/ disagree?
- Specific numerical reference to data
- Appropriate language used “*Supports my hypothesis*” (not ‘proves’ or ‘is correct’)
- Associated qualitative data add value to explanations.

### Conclusion (theory)-comparison to the scientific context

- Scientific explanation** for results
- Comparison with published data and theoretical texts.
- Sources cited appropriately
- Reference list provided in the appropriate format.

### Discussion of the strengths and weaknesses of the investigation

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li><input type="checkbox"/> Reference to error bars (or STDEV) with regard to variability of results</li> <li><input type="checkbox"/> <b>Analysis</b> of reliability of results:</li> <li><input type="checkbox"/> Are data sufficient to address the RQ?</li> <li><input type="checkbox"/> Was the range of the IV appropriate?</li> <li><input type="checkbox"/> Identify &amp; Explain anomalous data points</li> <li><input type="checkbox"/> Refer to quantitative data</li> </ul> | <p>Evaluate <i>random biological variation, measurement/ instrument errors, systematic error</i> (problems with the method) in terms of:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Possible effect on data</li> <li><input type="checkbox"/> Significance of the weakness or limitation in terms of the data set</li> </ul> <p><i>This can be clearly presented in a table</i></p> |
|--|--|

Time management or human error may be mentioned, though these are not scientific errors – they should be eliminated with good practical skills. The **focus** here should be on the **investigation/method**.

### Suggestions for the improvement and extension of the investigation

- For each weakness or limitation mentioned above, how could improved experimental design **remove** or **reduce** the impact of the error in terms of:
- Techniques used to collect and record data, including precision of equipment
  - Design of the investigation, including range of values chosen and repeats of each IV data point
  - Realistic, specific (not: “more time” or “more careful work”) and achievable improvements.
  - Suggestions for further investigation stated.

COMMUNICATION				
	Presentation of the investigation	Structure	Relevance	Terminology
4	Clear. Any errors do not hamper understanding of the focus, process and outcomes.	Well-structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way.	Relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation.	The use of subject specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding.
2	Unclear, making it difficult to understand the focus, process and outcomes	Not well structured and is unclear: the necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way.	The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information.	There are many errors in the use of subject specific terminology and conventions*.
0	Standard not reached.	Standard not reached.	Standard not reached.	Standard not reached.

Important aspects to take into account:

- Tables & graphs do not break across pages
- Graphs clear, colouring appropriate
- Effective use of space

PERSONAL ENGAGEMENT			
	Evidence of personal engagement with exploration.	The justification given for choosing the research question and/or the topic under investigation.	Evidence of personal input and initiative in the designing, implementation or presentation.
2	Clear with significant independent thinking, initiative or creativity.	Demonstrates personal significance, interest or curiosity.	A lot
1	Limited with little independent thinking, initiative or insight.	Does not demonstrate personal significance, interest or curiosity.	Little
0	Standard not reached.	Standard not reached.	Standard not reached.