Unit 3: Science Investigation Skills

Level: 3
Unit type: External
Guided learning hours: 120

Unit in brief

Learners will cover the stages involved and the skills needed in planning a scientific investigation: how to record, interpret, draw scientific conclusions and evaluate.

Unit introduction

Advancement in science and technology has produced great benefits for society. This advancement depends on research and investigatory approaches in science and technology. In research, development, analytical and industrial laboratories, laboratory technicians and scientists are employed to safely carry out practical investigations, or follow prescribed laboratory procedures. They repeat measurements to obtain consistent, reliable results. They use investigatory skills, including planning, recording and interpreting data, analysing and evaluating findings in order to test a hypothesis to inform further research and development.

In this unit, you will develop the essential skills underpinning practical scientific investigations. As well as drawing on Unit 1 and Unit 2, these skills will be delivered through subject themes ranging from enzymes and diffusion to electrical circuits. The subject themes provide different contexts for the development of the investigative skills. In this unit you will draw on your learning from across your programme to complete assessment tasks.

Science investigative skills will help you in many scientific or enquiry-based learning courses in higher education, as well as prepare you for employment in a science-related industry.

Summary of assessment

This unit will be assessed through a written taskbook (Part B) worth 60 marks. The task is set and marked by Pearson and will be completed in one sitting, within a supervised assessment period of one week.

The assessment task will assess learners’ ability to plan, record, process, analyse and evaluate scientific findings, using primary and secondary information/data.

In order to complete the written task, learners will need to obtain results/observations from a practical investigation. Pearson will release teacher/technician notes and guidance to centres to enable sufficient time for resource and trialling of the practical investigation.

A task brief (Part A) and the written taskbook (Part B) will then be released by Pearson two weeks before the supervised assessment period. The task brief will allow learners to complete the practical investigation and obtain results required to complete their written taskbook, in one sitting lasting one hour and 30 minutes, under supervised conditions.

It is important to note that learners will not be assessed on their practical competence in this external assessment.

The assessment availability is in December/January and May/June. The first assessment availability is May/June 2017.

Sample assessment materials will be available to help centres prepare learners for the assessment.
Assessment outcomes

**AO1** Demonstrate knowledge and understanding of scientific concepts, procedures, processes and techniques and their application in a practical investigative context

**AO2** Interpret and analyse qualitative and quantitative scientific information to make reasoned judgements and draw conclusions based on evidence in a practical investigative context

**AO3** Evaluate practical investigative procedures used and their effect on the qualitative and quantitative scientific information obtained to make reasoned judgements

**AO4** Be able to make connections between different scientific concepts, procedures, processes and techniques to make a hypothesis and write a plan for a practical investigation
Essential content

The essential content is set out under content areas. Learners must cover all specified content before the assessment.

A Planning a scientific investigation

A1 Developing a hypothesis for an investigation
- Be able to formulate a hypothesis or a null hypothesis based on relevant scientific ideas.

A2 Selection of appropriate equipment, techniques and standard procedures
- Be able to select and justify the use of equipment/techniques/standard procedures for quantitative and/or qualitative investigations.

A3 Health and safety associated with the investigation
- Understand risks and hazards associated with the investigation.

A4 Variables in the investigation
- Independent.
- Dependent.
- Control.

A5 Method for data collection and analysis
- Be able to produce a clear, logically ordered method to obtain results.
- Be able to select relevant measurements and the range of measurements to be recorded.
- Understand the importance of obtaining data accurately/reliably and to appropriate levels of precision.
- Understand how variables can be controlled/measured/monitored.
- Understand how the data/information can be analysed.

B Data collection, processing and analysis/interpretation

B1 Collection of quantitative/qualitative data
- Be able to collect data accurately/reliably and to appropriate levels of precision.
- Be able to tabulate data in a clear and logical format using correct headings with units where appropriate.
- Be able to identify anomalous data and take appropriate action.
- Be able to recognise when it is appropriate to take repeats.
- Be able to make qualitative observations and draw inferences.

B2 Processing data
- Be able to carry out relevant calculations where appropriate, involving:
  - mean and standard deviation
  - use and interpretation of error bars
  - use of statistical tests, including t-test, chi-squared and correlation analysis
  - use of formulae
  - transposition of formulae
  - conversion of units
  - use of standard form
  - percentage error of measuring equipment.
- Be able to display data in an appropriate format, including:
  - choosing an appropriate graph/chart/tables
  - correct plotting/labelling/scales.
C Drawing conclusions and evaluation

C1 Interpretation/analysis of data
- Be able to identify trends/patterns in data.
- Be able to compare primary and secondary data.
- Be able to use data to draw conclusions that are valid and relevant to the purpose of the investigation.
- Interpretation of statistical tests using tables of critical values and a 5% significance level, with reference to the null hypothesis.

C2 Evaluation
- Be able to make any recommendations for improvements to the investigation.
- Be able to explain anomalous data.
- Be able to determine quantitative and discuss qualitative sources of error.
- Be able to discuss evidence of the reliability of the data collected during the investigation.
- Be able to identify strengths and weaknesses within method/techniques/standard procedures/equipment used.
- Be able to suggest improvements to an investigation.

D Enzymes in action

D1 Protein structure
- Peptide linkage.
- Active sites.
- Denaturation.

D2 Enzymes as biological catalysts in chemical reactions
- Collision theory.
- Formation of enzyme-substrate complex.
- Specificity of enzymes brought about by the need for matching of substrate and active site.
- Lowering of activation energy.
- Changing substrate concentration changes the rate at which substrate molecules will join active sites.
- Importance of measuring initial rates of reaction.

D3 Factors that can affect enzyme activity
- Temperature.
- pH.
- Substrate and enzyme concentration.

E Diffusion of molecules

E1 Factors affecting the rate of diffusion
- Concentration gradient.
- Shape and size of molecules.
- Temperature.
- Distance.
- Surface area.

E2 Arrangement and movement of molecules
- Random movement of molecules in liquids and gases.
- Diffusion takes place along a concentration gradient until dynamic equilibrium is reached.
F Plants and their environment

F1 Factors that can affect plant growth and/or distribution
- Human effects – trampling.
- Soil pH and aeration.
- Light intensity – shaded and unshaded areas.
- Temperature.
- Presence of water – moisture and rainfall.
- Mineral ions.

F2 Sampling techniques
- Understand the importance of random sampling in collecting reliable and valid data for analysis.
- Select appropriate ecological sampling techniques to investigate the effect of abiotic factors on plant populations, including:
  - transects
  - quadrats (open and gridded)
  - point frames.

F3 Sampling sizes
- Select sample sizes for investigation with regards to practical constraints and the need to collect sufficient data to make valid conclusions.

G Energy content of fuels

G1 Fuels
- Petrol, paraffin, food, cooking oil, methanol, ethanol, propan-1-ol, butan-1-ol, pentan-1-ol, wax temperature.

G2 Hazards associated with fuels
- Flammability.
- Toxicity.
- Risk of explosion.
- Harmful effects of products of incomplete combustion.
- Pollution from sulphur impurities.

G3 Units of energy
- Define – joules, kJ, calories (1 g by 1 °C), kilocalories, kWh.
- The heat capacity of water will be given if required.
- Calculate heat energy supplied by a fuel to water using:
  - heat energy = mass of water \times \text{specific heat capacity of water} \times \text{temperature rise of water}.
- Calculate heat energy released from a fuel in kJ mol\(^{-1}\).
H Electrical circuits

H1 Use of electrical symbols to design circuits
- Battery.
- Ammeter.
- Voltmeter.
- Bulbs.
- Resistors.
- Diodes.

H2 Equations
- Power = $VI$ (voltage $\times$ current).
- Power = \frac{\text{work done}}{\text{time}}
- Work done = energy supplied or transformed.

H3 Energy usage
- Consider different domestic appliances to calculate energy usage and relate fuse size to power.
Grade descriptors

To achieve a grade a learner is expected to demonstrate these attributes across the essential content of the unit. The principle of best fit will apply in awarding grades.

Level 3 Pass

Learners will demonstrate a sound knowledge and understanding of scientific concepts, procedures, processes and techniques and their application within a practical context. Learners will interpret and analyse their own data and secondary data, leading to reasoned judgements on the qualitative and quantitative data they have collected during their investigation. They will be able to draw links between different scientific concepts, procedures, processes and techniques to make a hypothesis and plan an investigation. Learners will be able to make evaluative judgements on scientific data, processes and procedures that make reference to scientific reasoning.

Level 3 Distinction

Learners will demonstrate a thorough understanding of how scientific concepts, procedures, processes and techniques can be integrated and applied within a practical context. They will interpret, analyse and evaluate their own collected data and secondary data to support judgements and conclusions drawn. Learners will use and integrate knowledge and understanding of scientific concepts, procedures, processes and techniques to make a hypothesis and plan an investigation that is fully supported by scientific reasoning. Learners will be able to provide rationalised evaluative judgements on scientific data, processes and procedures that are fully supported by scientific reasoning.

Key terms typically used in assessment

The following table shows the key terms that will be used consistently by Pearson in our assessments to ensure students are rewarded for demonstrating the necessary skills.

Please note: the list below will not necessarily be used in every paper/session and is provided for guidance only.

Only a single command word will be used per item.

<table>
<thead>
<tr>
<th>Command or term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add/label</td>
<td>Learners label or add to a stimulus material given in the question, for example labelling a diagram or adding units to a table.</td>
</tr>
<tr>
<td>Assess</td>
<td>Learners give careful consideration to all the factors or events that apply and identify which are the most important or relevant. Make a judgement on the importance of something, and come to a conclusion where needed.</td>
</tr>
<tr>
<td>Calculate</td>
<td>Learners obtain a numerical answer, showing relevant working. If the answer has a unit, this must be included.</td>
</tr>
<tr>
<td>Comment on</td>
<td>Learners synthesise a number of variables from data/information to form a judgement. More than two factors need to be synthesised.</td>
</tr>
<tr>
<td>Compare</td>
<td>Learners look for the similarities and differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question. The answer must include at least one similarity and one difference.</td>
</tr>
<tr>
<td>Complete</td>
<td>Learners complete a table/diagram.</td>
</tr>
<tr>
<td>Convert</td>
<td>Relates to unit conversion, for example g to kg.</td>
</tr>
<tr>
<td>Deduce</td>
<td>Learners draw/reach conclusion(s) from the information provided.</td>
</tr>
<tr>
<td>Command or term</td>
<td>Definition</td>
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<td>---------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Derive</td>
<td>Learners combine two or more equations or principles to develop a new equation.</td>
</tr>
<tr>
<td>Describe</td>
<td>Learners give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason.</td>
</tr>
<tr>
<td>Determine</td>
<td>Learners’ answers must have an element which is quantitative from the stimulus provided, or must show how the answer can be reached quantitatively. To gain maximum marks there must be a quantitative element to the answer.</td>
</tr>
<tr>
<td>Discuss</td>
<td>Learners identify the issue/situation/problem/argument that is being assessed in the question. Explore all aspects of an issue/situation/problem argument. Investigate the issue/situation etc. by reasoning or argument.</td>
</tr>
<tr>
<td>Draw</td>
<td>Learners produce a diagram, either using a ruler or using freehand.</td>
</tr>
<tr>
<td>Estimate</td>
<td>Learners give a numerical value expected based on data given.</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Learners review information then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject’s qualities and relation to its context.</td>
</tr>
<tr>
<td>Explain</td>
<td>Learners’ explanations require a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.</td>
</tr>
<tr>
<td>Give/state/name</td>
<td>These generally require recall of one or more pieces of information.</td>
</tr>
<tr>
<td>Give a reason why</td>
<td>When a statement has been made and the requirement is only to give the reasons why.</td>
</tr>
<tr>
<td>Identify</td>
<td>Usually requires some key information to be selected from a given stimulus/resource.</td>
</tr>
<tr>
<td>Plot</td>
<td>Learners produce a graph by marking points accurately on a grid from data that is provided and then drawing a line of best fit through these points. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.</td>
</tr>
<tr>
<td>Predict</td>
<td>Learners give an expected result.</td>
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<tr>
<td>Record</td>
<td>Specifically relates to devising a results table.</td>
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<tr>
<td>Show that</td>
<td>Learners prove that a numerical figure is as stated in the question. The answer must be to at least one more significant figure than the numerical figure in the question.</td>
</tr>
<tr>
<td>Sketch</td>
<td>Learners produce a freehand drawing. For a graph this would need a line and labelled axis with important features indicated. The axes are not scaled.</td>
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<tr>
<td>State and justify/identify and justify</td>
<td>When a selection is made and a justification has to be given for the selection.</td>
</tr>
<tr>
<td>State what is meant by</td>
<td>When the meaning of a term is expected but there are different ways in which this meaning can be described.</td>
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<tr>
<td>Write</td>
<td>When the question asks for an equation.</td>
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</table>
Links to other units

This unit links to:

- Unit 2: Practical Scientific Procedures and Techniques
- Unit 4: Laboratory Techniques and their Application
- Unit 6: Investigative Project.

This unit also links to a wide range of optional units available across the qualification.

Employer involvement

Centres may involve employers in the delivery of this unit if there are local opportunities. There is no specific guidance related to this unit.