Unit 4 Investigative Project Skills

Delivery guidance

This unit enables learners to gain and demonstrate the skills required to research, plan, carry out, communicate and evaluate the findings of an investigative project.

The unit has 120 guided learning hours (GLH). Learners are individually required to carry out an in-depth search, plan and produce a report to communicate findings; they will need to collaborate with you to do this. The unit is internally assessed via centre-designed assignments or the Authorised Assignment Briefs.

Approaching the unit

This is a practical unit that gives your learners the opportunity to carry out a practical, vocational, investigate project into a topic in which they are interested and have chosen in consultation with you. Learners can use and adapt some of the key skills and techniques that they have previously used in a work experience placement, in education, or in other practical experimental units on the course.

Universities and industries welcome learners who have good knowledge and understanding of practical, experimental and project management skills. Learners will learn and reinforce the importance of a number of these key skills by carrying out a literature search and review, planning and implementing their project, collecting and analysing data, and presenting results from their chosen project in an evaluative report.

To complete this unit, your learners will need access to a laboratory and a range of equipment, apparatus and materials for practical work. They will also need logbooks and diaries to log their progress as they work towards completing their projects. Access to research materials – including the internet, software packages, journals, magazines and books – is essential. Some examples of delivery methods proposed for this unit are:

- discussions – class and small group discussions on the various stages of the project and the use of project case studies
- tutor presentation and guidance – briefing and monitoring learners at each stage of the project
- individual learner activity, during which learners complete each stage of the project
- video clips, from which learners can learn and reinforce their knowledge about different experimental and practical techniques and methods.

Learners need to plan and undertake extensive practical work, and assessors will assess and validate this for the unit. Centres must ensure they comply with all health and safety guidance and regulations. Learners must be encouraged to risk assess practical work to help ensure they are aware of the safety issues and follow the relevant procedures and guidelines.

Learning aim A asks learners to undertake a literature search and review, and to produce an investigative project proposal. Introduce the unit by giving an overview and describing how it fits within the qualification and relates to other units. Discuss with learners the various types of vocational investigative science projects that previous learners have carried out, and have learners share experiences of any assignments and projects they themselves have completed previously. Then discuss with learners ideas about what sort of project they would like to carry out. Giving a suggested list of projects could be useful in sparking imagination and enthusiasm. Learners need to be aware of the requirements of project proposal aspects, such as the need for a title, aims and SMART objectives, a hypothesis, variables, resources and potential limitations for the project. You need to introduce learners to ways in which literature searches and reviews should be carried out, analysed, evaluated and referenced. Teaching and learning opportunities should be presented to learners to enable them to develop skills in using systems and technology in their literature search and review. Each learner must gain approval for their project from you. You need to give learners opportunities to develop critical thinking skills while carrying out their literature search. They must consider potential limitations in their project proposal and justify their chosen hypothesis. Their project proposal could also include non-routine problem-solving skills and creative solutions.

Learning aim B asks learners to produce a working plan for an investigative project, based on the proposal. Learners need to understand the importance of schedules of work, timelines, milestones and target dates. This will help prepare them to write their own schedule of work and to monitor their progress, using logbooks and diaries. Learners should complete a schedule for their own projects, using a template with realistic timelines, and taking into account the number of hours available. You could brief the learners on how to go about producing a plan, using a typical template for this level of learner, and how they would need to implement the project using the required resources. You could also highlight the need for learners to plan how to set up equipment, instruments or sensors, or prepare resources for fieldwork. Help learners decide how they are going to collect, record, analyse and present data. You should discuss with learners the need to ensure they have thought about contingency planning and what remedial action to take if things don't go as planned. Learners need to use problem-solving skills in contingency planning and justify changes to their project plan. Brief learners on health and safety issues, explain who will carry out risk assessments, and ensure they take into account ethical and legislative issues. You could also ask a guest speaker to outline the importance of health and safety – the speaker could be a health and safety representative from your centre or an outside speaker.

Learning aim C asks learners to undertake the project, collecting, analysing and presenting the results. It will be assessed alongside learning aim D. You could introduce the implementation stage by ensuring that learners are prepared and discussing any issues that they have before they go ahead. Learners need to understand the approved procedures and practices, and adhere to health and safety requirements, outcomes of risk assessment and ethical considerations. They will need to take responsibility for showing you that they are keeping their logbooks and diaries up to date. Brief learners about presentation of data; learners need to take responsibility for ensuring that their data and statistical analysis are processed by using the correct validation methods for their presentation, and that it is fit for purpose.

Learning aim D asks learners to communicate and evaluate the findings of their project. Brief learners about methods of evaluating their findings, using scientific protocol and terminology. You should include advice about referencing and creating a bibliography for the final project report. You could lead a class discussion considering the most effective methods of evaluating their findings.

Learning aims C and D encourage learners to develop negotiating and influencing skills. Critical thinking and problem-solving skills are also developed as learners justify and reflect on their conclusions and the limitations of their project.

Assessment model

Learning aim	Key content areas	Recommended assessment approach
A Undertake a literature search and review to produce an investigative project proposal	**A1** Literature review **A2** Investigative project proposal	Produce a project proposal (including objective, hypothesis, variables, resources, safety and limitations), supported by a literature search.
B Produce a working plan for an investigative project based on the proposal	**B1** Schedule **B2** Plan **B3** Health and safety and ethical considerations	Produce a working plan (including schedule, method, risk assessment and contingency planning), supported by a logbook of trial runs.
C Safely undertake the project, collecting, analysing and presenting the results	**C1** Experimental procedures and techniques **C2** Collect and collate data **C3** Data presentation and interpretation **C4** Analyse data	Observation records. Witness testimonies and/or annotated photographs of equipment/techniques in use by learner. Laboratory logbook authenticated by assessor/ project supervisor. Report including data, processing and presentation, statistical analysis, conclusion and evaluation. Presentation by learner and notes on the investigative project outcomes to the class/ supervisor. Observation records, witness testimonies or self-assessment record.
D Communicate and evaluate the findings of the project	**D1** Scientific report for the investigative project **D2** Scientific evaluation of findings	

Assessment guidance

This is an internally assessed unit of 120 guided learning hours, with a maximum of three assignments – one each for learning aim A and learning aim B, while learning aims C and D are funnelled and must be assessed using one assignment. This is a practical-based unit and learners must have access to a laboratory or field study area and appropriate equipment.

Learners must be given the opportunity to acquire new skills in addition to developing existing skills and knowledge.

Learning aim A requires learners to carry out in-depth research of relevant literature. This must be corroborated by a fully referenced bibliography. Learners must produce a project proposal, including a hypothesis and safety considerations. They must explain, analyse and justify these, along with variables, resources, how data will be recorded and potential limitations.

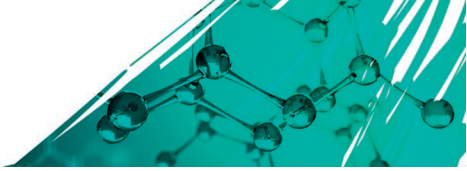
For learning aim B, a realistic project proposal that gives a method that can be followed by the assessor, health and safety considerations, risk assessments and contingency planning will be included. Following a trial run(s) and implementation of the plan, the effectiveness of the plan must be assessed and changes made must be justified.

Learning aims C and D must be assessed together.

Learning aim C requires the learners to safely undertake their project and draw conclusions from data they have collected, presented and analysed. Statistical analysis of data must be carried out and will depend on the nature of the project undertaken. Learners will need support and guidance during teaching and learning to understand statistical tests. Learners must assess experimental techniques, data collection, and the validity and reliability of the data collected.

Learners need to produce their final report in a style that allows assessors to assess the evidence presented for each individual criterion. The report must be coherent and use correct, formal reporting protocols, i.e. it must be written in an impersonal style, using third person, past tense and including references and a bibliography. The evaluation of methods must cite limitations and errors, suggest improvements and make recommendations for further investigation(s).

All learners must independently generate individual evidence that can be authenticated by a third party. Appropriate methods for this could be video, annotated photographs and observation and/or witness statements. Technical staff could complete witness statements for relevant assessment criteria. Observation records alone are not sufficient sources of learner evidence; they should be used to support the original learner-generated evidence in the project report. This evidence could be in the form of a reflective account of what was done, results, logbooks/diaries, etc.



Getting started

This gives you a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 4: Investigative Project Skills

Introduction

Begin with a tutor-led presentation introducing the unit to learners. Discuss the unit specification, learning outcomes and assessment criteria.

Splitting learners into pairs or small groups to map their current understanding of each of the three learning aims would elicit information about current learner knowledgeand understanding, and assist planning for delivery of the unit.

Learning aim – A Undertake a literature search and review to produce an investigative project proposal

A1 and A2

- Learners will need to be formally introduced to the Scientific Method. This could be done using everyday observation (e.g. observing birds on a bird feeder). Encourage learners to come up with a question, hypothesis and prediction, and to create an outline plan to test the hypothesis.
- Use a video/song from the internet about the Scientific Method to stimulate learners.
- Encourage learners to produce an annotated flow chart/concept map of the Scientific Method to consolidate understanding of how to plan a project.
- Lead a discussion about hypothesis/null hypothesis and predictions, and give examples. Using examples of hypotheses and predictions, encourage learners to identify independent and dependent variables.
- Your input may be required to help learners understand how to carry out a literature search, identify relevant sources, and analyse and explain its relevance to investigations.
- Ask learners to collect references/hard copies of different types of reports (newspaper articles from different sources, social media reports, Wikipedia, scientific journals, news broadcasts), on a current issue to identify the type of audience they target, accuracy/bias, the relevance of the sources used and the date of publication.
- Learners will require practical opportunities to practise using the equipment they will use for their project. They should be able to select the most appropriate equipment for their project requirements and will need to learn how to calibrate it. Lead a practical session and encourage learners to carry out a number of tasks to enable them to become familiar with the equipment (e.g. heating water using different types of thermometer, or measuring quantities using different equipment to ensure accuracy).
- Learners may need reminders about how best to record and present data – tables, graphs, statistical analysis, etc. This will also be covered in learning aim C.
- Hold a discussion about health and safety and risk assessments associated with investigative work.
- Ask guest speakers to come in and discuss science projects, and the importance of project management skills to employability. This is a useful way of linking the work learners are doing in this unit to the industries in which they may hope to be employed in the future.

- Brief learners about the choice of relevant areas of study for a project. Ask learners to collaborate in small groups to come up with examples of different projects that they have experienced. Each learner could then contribute to a class discussion on the type of projects they have experienced in education or through work experience. Give learners the titles of previous projects carried out at the centre and any case studies of those projects.
- Put learners into small groups and present them with potential topics for study. They should discuss and feed back on areas/types of literature that would need to be researched, possible hypotheses, an outline plan and timescale for the project. They should also consider what equipment might be needed, health and safety considerations, what trials need to be carried out, and what data they need to collect.
- Give a presentation to learners on how to go about carrying out a literature search and review. You should cover identification, location, reliability, extraction and referencing of sources of information.
- Use a video from the internet to demonstrate referencing.

A2

- Brief learners about what needs to be included in a project proposal. Their proposals must include a title, aims and objectives, hypothesis, background and rationale, variables, resources, safety and limitations.
- Encourage learners to discuss and consider resources, and any potential limitations to the resources they have available. How will the resources available contribute to the accuracy and validity of results that will be obtained?
- Discuss how and why decisions about the project, the influence of reviewing literature and equipment selected must be justified.
- Ask learners to decide, as individuals or in a group, the area of study they are interested in, its vocational aspect and industrial sector. Learners should discuss their area of study with you for approval.
- Once learners have acquired the relevant skills and knowledge, they should use the assignment brief to work independently to produce the required evidence.
- Assessment requires learners to choose a scientific area for an investigative project. They must carry out a literature search, produce a project proposal with a hypothesis, and identify resources required and safety considerations.

Learning aim B – Produce a working plan for an investigative project based on the proposal

B1, B2 and B3

- Brief learners on how to design a schedule of work. Include a start date, completion date, realistic timelines and milestones. You should discuss how best to set and achieve target deadlines. Give learners logbooks and diaries to record their progress as they work through their projects.
- Discuss ethical considerations about experimental design.
- Brief learners about how best to produce a realistic working plan. Learners must consider how they will implement their project with the resources available, and how they are going to collect, record, analyse and present data.
- You should then brief learners on contingency planning and lead a discussion about remedial actions to make changes to a plan.

- Give a presentation and discuss with learners the need for health and safety, risk assessments and ethical considerations, taking into account legislative, COSHH and PPE requirements.
- You could ask a health and safety representative from the centre to give a presentation about health and safety in the context of learners' projects, or invite an outside health and safety guest speaker.
- Discuss the need for trial runs. Once learners are confident in planning an investigation, they should independently attempt the assignment. Make time available for learners to carry out trial runs for their project and amend the proposal/method accordingly
- For assessment, learners must produce a realistic working plan, including a method, schedule, risk assessments and contingency planning. They must be able to assess the effectiveness of the plan and justify changes they made after carrying out trial runs. Learners must give evidence that they are monitoring their projects, by using logbooks and diaries.

Learning aim C – Safely undertake the project, collecting, analysing and presenting the results

Learning aim D – Communicate and evaluate the findings of the project

Learning aims C and D will be taught and assessed as one assignment.

C1

- Begin by discussing with learners the need for good experimental procedures, observation skills, practical techniques and skills. Learners need to ensure they are using safe working practices when following procedures and when using equipment and instruments.
- Discuss PPE and legislation that may need to be considered.
- Learners will need an opportunity to familiarise themselves with the equipment they intend to use for their project.

C2, C3, C4 and D2

- Introduce and discuss the need to collect, record and analyse data, taking into account the need for accuracy, reliability, validity, precision and integrity, using appropriate methods of data processing and analysis.
- Using a recent practical lesson that learners participated in, ask them to discuss and justify the methods used to collect data. They should consider the accuracy of the equipment used in terms of validity and reliability.
- Teach learners about processing data and how to present it in an appropriate format. This should be done in all practical lessons for all units, and you should work with learners to develop their skills in this area.
- Give learners sets of results, and ask them to consider the best ways to analyse and present them for different types of practical work.
- Ask learners to identify anomalous results in sets of data they have collected for other units or have been given by you. Follow this with a discussion of how anomalous results should be dealt with and the need for repeats or further investigation.
- Give learners the results from practical work and ask them to make conclusions.
- Learners may require considerable support to understand statistical analysis, including standard deviation, error bars, t-test, chi-square test and correlation analysis and assessment. Learners must understand the differences between accuracy, reliability and

precision. Learners following a maths course, or a maths tutor from the centre, could be asked to lead a presentation about some of these methods.

- Ask learners to find examples of different methods used to present data, e.g. class intervals, tallying, tabulation, graphs, pie charts, etc. These can be discussed to identify the need for accuracy, integrity, precision and use of correct units and headings. Ask learners to justify why one type of presentation has been used instead of an alternative.
- Give a tutor presentation defining accuracy, reliability and precision, and how these link to integrity when collecting and presenting data. This could be followed by small groups of learners working together to find examples of each term to check knowledge and understanding.
- Encourage learners to understand the need for skills such as time management, keeping to and following appropriate standards and protocols, demonstrating safe working practice, giving and receiving constructive feedback, etc. Learners should be resourceful and show initiative where possible.
- Remind learners about monitoring their projects using logbooks and diaries.

D1

- Introduce the topic of how to write scientific reports and cover scientific protocol and terminology.
- Brief learners about the structure and format of report writing. Emphasise the use of the past tense, correct scientific terminology, referencing and a bibliography. The references and bibliography must be correctly written, and it may be helpful to review the Harvard referencing system with learners.
- Learners could look at examples of published scientific reports and analyse them in terms of style, format and type of communication.
- Once learners are confident in the format of a scientific report and their evaluative skills, they should attempt the assignment.
- For assessment, they must demonstrate practical skills carrying out their project. They must collect, present and statistically analyse data, and interpret the results to make valid conclusions. The report they produce must be coherent, use correct scientific protocols and terminology, and analyse, assess, justify and evaluate the findings from the project. They must make recommendations for improvements for future investigations.

Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit links to:

- *Unit 1: Principles and Applications of Biology I*
- *Unit 2: Principles and Applications of Chemistry I*
- *Unit 3: Principles and Applications of Physics I*
- *Unit 5: Principles and Applications of Biology II*
- *Unit 6: Principles and Applications of Chemistry II*
- *Unit 7: Principles and Applications of Physics II*

Other units may be relevant, depending on the project selected by the learner.

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC International L3 Qualifications in Applied Science. Check the Pearson website at: (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

Hartley, J, Annets, F, Meunier, C, Llewellyn, R, Hocking, S, Peers, A and Parmar, C – *BTEC Nationals Applied Science: Student Book Level 3* (Pearson, 2016) ISBN 9781292134093. This book is a useful general reference and contains a section on scientific investigation.

Coyne, GS – *The Laboratory Companion: A Practical Guide to Materials, Equipment and Techniques* (Wiley-Blackwell, 2005) ISBN 9780471780861. Contains information about material, equipment and techniques.

Kumar, R – *Research Methodology: A step by step guide for beginners* (Sage Publications Ltd 2019) ISBN 9781526449900

Journals

- *Nature*
- *New Scientist*
- *Scientific American*
- Technical journals requiring high-level reading skills and the ability to use and understand technical terms. They contain articles and the latest news and research into related topics.

Videos

- The Khan Academy has a useful video on the Scientific Method which can be found by searching online for 'The Khan Academy', and then searching their site for 'The Scientific Method video'.
- There is a song about the Scientific Method on YouTube. It can be found by searching for 'Scientific Method Song'.

Websites

- The Association for Science Education has a useful website that can be found by searching online for 'The Association for Science Education'.
- The HSE has a useful website with information about the Control of Substances Hazardous to Health (COSHH). It can be found by searching online for 'HSE'.
- The Institute of Physics has a useful website that can be found by searching online for 'The Institute of Physics'.
- The National STEM Centre website can be found by searching online for 'STEM'.
- The Royal Society of Biology has a useful website that can be found by searching online for 'The Royal Society of Biology'.
- Study.com has some useful information about planning a scientific investigation. It can be found by searching online for 'Study.com', and then searching their website for 'planning a scientific investigation or experiment'.
- Science Made Simple has some useful information about the Scientific Method on their website. It can be found by searching online for 'Sciencemadesimple.com', and then searching their website for 'the Scientific Method'.
- Science Buddies has a section on their website about the Scientific Method. It can be found by searching online for 'science buddies', and then searching their site for 'The Scientific Method'.
- The University of Leicester website has a useful page on how to write a literature review. It can be found by searching online for 'The University of Leicester' and then searching their site for 'how to do a literature review'.

Pearson is not responsible for the content of any external internet sites. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling learners to access them through the school/college intranet.