Science
Guidance for Key Stages 2 and 3

Yr Adran Plant, Addysg, Dysgu Gydol Oes a Sgiliau
Department for Children, Education, Lifelong Learning and Skills

Llywodraeth Cynulliad Cymru
Welsh Assembly Government
Science
Guidance for Key Stages 2 and 3

Audience
Teachers at Key Stages 2 and 3; local education authorities; tutors in initial teacher training; and others with an interest in continuing professional development.

Overview
These materials provide key messages for planning learning and teaching in science. They include profiles of learners’ work to exemplify the standards set out in the level descriptions and illustrate how to use level descriptions to make best-fit judgements at the end of Key Stages 2 and 3.

Action required
To review learning plans and activities, and to prepare to make judgements at the end of Key Stages 2 and 3.

Further information
Enquiries about this document should be directed to:
Curriculum and Assessment Division
Department for Children, Education, Lifelong Learning and Skills
Welsh Assembly Government
Floor 10, Southgate House
Wood Street
Cardiff
CF10 1EW
Tel: 0800 083 6003
Fax: 029 2037 5496
E-mail: C&A3-14.C&A3-14@wales.gsi.gov.uk

Additional copies
Can be obtained from:
Tel: 0845 603 1108 (English medium)
0870 242 3206 (Welsh medium)
Fax: 01767 375920
e-mail: dcells1@prolog.uk.com
Or by visiting the Welsh Assembly Government’s website
www.wales.gov.uk/educationandskills

Related documents
Science in the National Curriculum for Wales; Skills framework for 3 to 19-year-olds in Wales; Making the most of learning: Implementing the revised curriculum; Ensuring consistency in teacher assessment: Guidance for Key Stages 2 and 3 (Welsh Assembly Government, 2008)

This guidance is also available in Welsh.
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Contents

Introduction 2
Using these materials 4

Section 1
Key messages for learning and teaching in science 7

Section 2
Expectations and progression in science 23

Section 3
Making judgements at the end of Key Stages 2 and 3 53

Key Stage 2
David  Level 3 56
Mia  Level 4 66
Tom  Level 5 80

Key Stage 3
Sian  Level 5 95
Amy  Level 6 109
Ben  Level 7 127

Useful information and websites 139

Acknowledgements 141
Introduction

The programmes of study set out the opportunities that learners should be given at each key stage and provide the basis from which you, as a teacher, can plan learning and teaching. They are divided into two sections, Skills and Range. The Skills section lists the skills to be developed in a subject and the Range section comprises the opportunities and contexts through which these skills should be developed and consolidated.

Ongoing formative assessment – assessment for learning – lies at the heart of good teaching. Through the assessments that you make in the course of your teaching, you will build up an extensive knowledge of your learners’ strengths, as well as the areas that need further development, and you will use this knowledge to help you plan for the next steps in their learning. Learners will also gain understanding of specific learning goals and the associated success criteria so that, supported by you, they can develop their capacity for self-assessment and peer assessment. In this way, they can establish their current position, set and move towards targets, and discover if and when the targets have been reached. Individual targets are linked to improving the quality of a learner’s work, as highlighted through formative feedback, and are therefore linked to success criteria for specific tasks. Level descriptions do not make effective targets as these describe attainment across the breadth of the programme of study at the end of a key stage.

Level descriptions can help to inform your planning, teaching and assessment at Key Stages 2 and 3 by indicating expectations at particular levels and progression in the subject. Evidence from assessment for learning will indicate where more time is needed to consolidate learning and when learners are ready to move on. You may wish to keep some evidence so that you can discuss a learner’s work and progress with them and/or with colleagues or parents/guardians. However, there is no statutory requirement to keep unnecessarily complex records or detailed evidence on every learner.

The essential function of level descriptions is to help you make rounded summative judgements at the end of Key Stages 2 and 3 about a learner’s overall performance. Level descriptions are designed neither to be used to ‘level’ individual pieces of work nor for the production of half-termly or termly data. It is only by the end of the key stage that you will have built up sufficient knowledge about a learner’s performance across a range of work, and in a variety of contexts, to enable you to make a judgement in relation to the level descriptions.
It may be that some learners will be more advanced in some aspects of the work than in others, and that no one level description provides an exact fit. That is to be expected, and the range of individual learners’ work included in these materials illustrates the making of best-fit judgements under those circumstances. Many schools/departments have found it helpful to develop their own learner profiles to support moderation of end of key stage judgements. These profiles also help to maintain a common understanding of standards when they are reviewed annually or refreshed when necessary.

When making judgements at the end of Key Stages 2 and 3, you should decide which level description best fits a learner’s performance. The aim is for a rounded judgement that:

- is based on your knowledge of how the learner performs across a range of contexts
- takes into account different strengths and areas for development in that learner's performance
- is checked against adjacent level descriptions to ensure that the level judged to be the most appropriate is the closest overall match to the learner’s performance in the attainment target.

National curriculum outcomes have been written for learners working below Level 1. These are non-statutory and guidance on their use is planned.
Using these materials

This booklet is divided into three sections.

Section 1 highlights key messages for learning and teaching in science.

Section 2 highlights expectations and progression in science.

Section 3 contains a series of learner profiles. These are designed to show the use of the level descriptions in coming to judgements about a learner’s overall performance at the end of Key Stages 2 and 3.

This booklet is for reference when you wish to:

• review your learning plans and activities
• consider the standards set out in the revised science Order
• work with other teachers to reach a shared understanding of the level descriptions
• prepare to make judgements at the end of the key stage
• develop your own learner profiles
• support transition from Key Stage 2 to Key Stage 3.

For ease of reference, the level descriptions are included in a leaflet with this booklet.

A CD-ROM is also included with this booklet. It contains a PDF version of Science in the National Curriculum for Wales, Skills framework for 3 to 19-year-olds in Wales and this guidance.

A composite poster of the strands in the level descriptions is also included with this guidance. This poster is to aid teachers planning for progression in science and identifying characteristics of level descriptions. It is not designed as a prompt for learners. The use of numbers, as in the level descriptions themselves, is against the fundamental principles of assessment for learning. Therefore, although the sharing of progression in science with learners is essential, the labelling of that progression with numbers is counterproductive in everyday classroom assessments.
This guidance is part of a series of materials that will help teachers at Key Stages 2 and 3 to implement the revised curriculum and its associated assessment arrangements. The series includes:

- *Making the most of learning: Implementing the revised curriculum* – overview guidance on implementing the new curriculum
- *Skills framework for 3 to 19-year-olds in Wales* – which includes guidance about progression in skills
- *Ensuring consistency in teacher assessment: Guidance for Key Stages 2 and 3*
- *A curriculum for all learners: Guidance to support teachers of learners with additional learning needs*
- specific guidance for all national curriculum subjects, personal and social education, careers and the world of work, and religious education.
Section 1

Key messages for learning and teaching in science
The revised curriculum is learner-centred and skills-focused. Significant changes have been made to the presentation and content of this revised curriculum, giving both opportunities and challenges for schools wanting to provide a relevant and motivating educational experience.

**Structure of the science programme of study**

Key to learners’ successful science experiences will be the planning and teaching of the programmes of study. These have been designed to offer teachers and learners:

- a focus on developing skills, particularly thinking, communication, ICT and number skills, woven throughout the programmes and linking with the non-statutory *Skills framework for 3 to 19-year-olds in Wales*
• continuity and progression 3–19, taking into account particularly the frameworks for the Foundation Phase (especially the Knowledge and Understanding of the World area of learning), personal and social education (PSE), 14–19 Learning Pathways (particularly approved science-related qualifications and careers and the world of work)

• opportunities to engage in contemporary issues and different types of activities to suit learners’ and teachers’ needs and schools natural and physical resources in different parts of Wales

• maximum flexibility in selecting appropriate, relevant content from the considerable range of opportunities to suit the needs, interests and preferred experiences of all learners

• opportunities to link across the Range of Interdependence of organisms, The sustainable Earth and How things work

• opportunities to link with other subjects, such as geography, design and technology and the PSE framework.

So that the revised science order is learner-centred, it has embedded within it assessment for learning vocabulary. It is essential that for learners to make progress, they know where they are in a learning continuum, where they need to get to and most importantly how to get there. There are many tools/strategies that can be employed to ensure that assessment for learning is at the heart of classroom pedagogy. These move the teacher away from instructing to being a facilitator of learning. This guidance shows many assessment for learning tools/strategies.

In Sian’s profile (Key Stage 3, Level 5), for example, the teacher models two investigative write-ups so that learners can determine success criteria before they carry out and write up their own investigation. The modelling takes place in the ‘What makes a good investigation?’ enquiry with Sian using these success criteria in ‘How does the surface area affect the rate of evaporation?’. In a few of the profiles the teacher uses traffic lights for learners to self-assess their understanding. Mia uses this tool/strategy in ‘How can a guitar make a sound’ (Key Stage 2, Level 4). Each activity sets out the ‘Next steps’ required for each learner to progress.

Generally these are written by the teacher however, at times they are written by the learner themselves. In Amy’s profile (Key Stage 3, Level 6) she sets her own targets relating to the science knowledge and understanding to be used for her ‘Limestone’ enquiry.
In order to be **relevant to all learners**, contemporary contexts have been included in the Range that give opportunities for learners to link their own experiences and current issues with scientific theory. In addition, statements within the programmes of study are more general in nature than previously to increase flexibility and better allow teachers to take account of learners’ prior learning. This enables teachers to better target gaps or misconceptions in learners’ skills, knowledge and understanding. Tom uses a concept map to ascertain his prior learning before he draws a ‘Map of the solar system’ (Key Stage 2, Level 5).

Both the contemporary nature and flexibility of statements should allow teachers to provide learning experiences that are **relevant to the 21st century**. An example of such a task can be found in Sian’s profile (Key Stage 3, Level 5), the ‘Energy Resources’ enquiry. Here learners are asked to produce a report for the school governors as to the advantages and disadvantages of using ‘fast growing’ trees as the school’s main energy resource. The task allows Amy, working collaboratively, to research sources in order to compare the burning of fossil fuels with ‘fast growing’ trees. This mirrors the current debate in many parts of Wales.
Science and skills across the curriculum

The revised national curriculum Order for science has a greater focus on learners' skills development. It has been written taking due account of the Skills framework, which includes developing thinking, communication, number and ICT, both within the programmes of study and the associated level descriptions. Opportunities to develop these skills are highlighted by the use of icons. The Skills framework has been written to show how learners acquire, develop and apply these skills across the curriculum.

All the programmes of study have been written in two sections; Skills and Range. The Skills section of the science programme of study includes the areas of Communication and Enquiry. This section gives opportunities for learners to develop their thinking, communication, number and ICT across the Range. It is expected that learning will take place through scientific enquiry.

Developing thinking

Learners develop their thinking across the curriculum through the processes of planning, developing and reflecting.

In science, learners follow the processes of planning, developing and reflecting in all areas of Enquiry, through which the Range is taught. Focused paired/group work allows such processes to be articulated within lessons so that learning and thinking strategies can be developed and applied to new situations leading to high quality outcomes.

When good quality learning occurs, the cycle of plan, develop and reflect forms a spiral taking place throughout the learning. Learners reflect as they plan and develop a task, ensuring that they think about their thinking and use these thoughts to amend and refine their learning. By linking their learning to prior skills, knowledge and understanding from both within and outside of school, learners embed their progress and develop their thinking. These skills can then be applied across all aspects of their lives.

1 The learning is intended here to refer to internal processes. It does not refer to a three part lesson.
Developing communication

Learners develop their communication skills across the curriculum through the skills of oracy, reading, writing and wider communication.

In science, learners communicate ideas, information and data in a variety of ways depending on the nature of the task, audience, purpose and the learners' own preferences. Communication can take a wide variety of forms, including the use of IT at times, and with increasing maturity should show progression in the use of scientific terminology, symbols and conventions and a more logical, systematic approach.

Much of the evidence in the profiles demonstrates the development of communication skills. Mia makes a simple presentation about Saturn in ‘Planet presentation’ (Key Stage 2, Level 4) whilst Amy makes a more refined presentation on ‘Insulin’ (Key Stage 3, Level 6). Sian’s work in the classifying and identifying enquiry ‘Vertebrate groups’ (Key Stage 3, Level 5) shows how clear, systematic organisation of findings is important.

Developing ICT

Learners develop their ICT skills across the curriculum by finding, developing, creating and presenting information and ideas and by using a wide range of equipment and software.

In science, learners use ICT for a number of purposes. They search for, access, collect, process and analyse relevant scientific evidence, information, ideas and data. They use ICT to present their evidence, information, ideas and data in the most appropriate form.
Developing number

Learners develop their number skills across the curriculum by using mathematical information, calculating and interpreting and presenting findings.

In science, learners work quantitatively to estimate and measure using non-standard and then standard measures, recording the latter with appropriate S.I. units. They use tables, charts and graphs to record and present information, which is part of Communication in science. With increasing maturity they draw lines of best fit on line graphs, use some quantitative definitions and perform scientific calculations.

Number skills are used by learners throughout the profiles. In the ‘Litter survey’ activity, David uses a tally chart, a class pictogram and then draws a bar chart in a given format (Key Stage 2, Level 3). Mia, in the ‘Making rockets’ activity, draws a table and a simple line graph with given axes (Key Stage 2, Level 4). In the Level 5 profiles, Tom (Key Stage 2) demonstrates he can select the most appropriate type of chart or graph in the activity ‘How can the brightness of a bulb in a circuit be changed?’. Sian (Key Stage 3) plots a line graph to describe the relationship between two continuous variables in the enquiry ‘How does the surface area affect the rate of evaporation?’. Amy can use appropriate axes and scales for a line graph to show her data effectively in ‘How does caffeine affect the heart rate?’ (Key Stage 3, Level 6). In Ben’s profile (Key Stage 3, Level 7), he demonstrates that he can use some quantitative definitions and perform calculations using the correct units in ‘Can you work out work done?’. Activities throughout the profiles demonstrate the use of internet searches, whilst in ‘Mission possible?’ (Key Stage 2, Level 5), Tom uses a spreadsheet to determine the outcomes of a space mission. Many of the activities require learners to use ICT to display data, information and ideas.
Science and learning across the curriculum

Curriculum 2008 provides opportunities for the development of the Welsh Assembly Government’s policies and cross-curricular themes, such as the Curriculum Cymreig, personal and social education and careers and the world of work, which includes equal opportunities, food and fitness and sustainable development.

At Key Stages 2 and 3, learners should be given opportunities to build on their experiences gained during the Foundation Phase, and to promote their knowledge and understanding of Wales, their personal and social development and well-being, and their awareness of the world of work.

Curriculum Cymreig

Learners aged 7–14 should be given opportunities to develop and apply knowledge and understanding of the cultural, economic, environmental, historical and linguistic characteristics of Wales.

At Key Stage 2 learners are required to compare two local environments, by carrying out fieldwork. A better understanding of the factors that each environment is dependent upon, should lead to greater concern about the environment in Wales.

In the profiles, further links to the Curriculum Cymreig are exemplified by Sian’s ‘Energy Resources’ enquiry, (Key Stage 3, Level 5) where learners are tasked with producing a report for the school governors as to the advantages and disadvantages of using ‘fast growing’ trees as the school’s main energy resource. In addition, in Amy’s ‘Limestone Enquiry’ (Key Stage 3, Level 6) learners are asked to produce a resource for a local steel company’s Visitors’ Centre.
**Personal and social education**

Learners should be given opportunities to promote their health and emotional well-being and moral and spiritual development; to become active citizens and promote sustainable development and global citizenship; and to prepare for lifelong learning.

The revised science Order provides a variety of opportunities for learners to explore a wide range of issues related to PSE.

Examples in the profiles include a ‘Litter survey’ by David (Key Stage 2, Level 3) and a ‘Caffeine Enquiry’ where Amy investigates the effects of caffeine on heart rate (Key Stage 3, Level 6).

**Careers and the world of work**

Learners aged 11–19 should be given opportunities to develop their awareness of careers and the world of work and how their studies contribute to their readiness for a working life.

Although the icon is not used in the Range section of the programme of study, the whole of the Skills section is relevant to learners’ development for the world of work as well as future employment in a scientific field. It is hoped that following the revised programme of study in its entirety will lead to a more scientifically literate workforce.
Learning in science

Progress from the Foundation Phase in Skills and Range has been mapped through Key Stages 2 and 3 and into the Key Stage 4 programme of study. This should ensure that there is continuity for learners across their compulsory schooling in science. The Progression in science statements have been written to give a summary of the whole of a phase or key stage. They show how progress in science across the Skills and Range sections is achieved.

The profiles evidence learners articulating their thoughts, ideas and findings providing them with opportunities to develop higher order thinking and focus more on assessment for learning. Classroom tasks and activities include many examples of paired and group work, so that learners are given time to ask questions, think and justify their thoughts to their peers before reaching conclusions. Collaborative learning produces higher quality outcomes and enables learners to take risks without fear of self-failure. The teacher was still able to assess individual learners’ progress by listening for a few minutes to their deliberations and asking some pertinent questions. Self and peer assessment by the learners at the end of each activity consolidate the teacher’s evidence of the process and the outcomes.

Science Enquiry

The science orders reference specific types of enquiry. The titles and definitions have been developed from the AKSIS project. It is recognized that there is some overlap when classifying enquiries in this manner. For example, several enquiry types require learners to look for patterns although overall the enquiry may be classified as a fair test enquiry. Similarly, learners are expected to use models in other types of enquiry. Here is a summary of the types of enquiry exemplified within this booklet.

2 AKSIS (ASE–King’s College Science Investigations in Schools) project, 1998

The project produced teaching materials and research reports for teaching specific aspects of enquiry, and produced recommendations based on an exploration of how enquiry was implemented in schools by using focus groups, and on a national questionnaire survey.
(a) Pattern-seeking

Pattern-seeking enquiries are similar to fair tests but start with the values of the dependent variable and try to identify the cause(s) (the independent variable). Often they are used to study natural events and in most cases they involve variables that are difficult to control. Surveys are also pattern-seeking enquiries where learners compare data to identify relationships and make causal links.

<table>
<thead>
<tr>
<th>Learner profile</th>
<th>Title of enquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>David KS2 L3</td>
<td>Comparing two environments</td>
</tr>
<tr>
<td>David KS2 L3</td>
<td>Litter survey</td>
</tr>
<tr>
<td>Ben KS3 L7</td>
<td>Respiration and combustion</td>
</tr>
</tbody>
</table>

(b) Exploring

Exploring involves learners looking for changes in just one variable at a time. For example, making careful observations of objects or events or making a series of observations or measurements of a natural phenomenon occurring over time. Often these enquiries generate questions that then lead to other types of enquiry, especially pattern-seeking ones.

<table>
<thead>
<tr>
<th>Learner profile</th>
<th>Title of enquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mia KS2 L4</td>
<td>The rocket launch</td>
</tr>
<tr>
<td>Mia KS2 L4</td>
<td>How can a guitar make a sound?</td>
</tr>
<tr>
<td>Tom KS2 L5</td>
<td>Questioning a solar system image</td>
</tr>
<tr>
<td>Tom KS2 L5</td>
<td>Moon Crash Landing 2020</td>
</tr>
<tr>
<td>Sian KS3 L5</td>
<td>What makes a good investigation?</td>
</tr>
<tr>
<td>Amy KS3 L6</td>
<td>Melting ice</td>
</tr>
</tbody>
</table>
(c) Classifying and identifying

Classifying is a process of arranging a large range of objects or events into manageable sets according to their features or the way they behave. Identifying is a process of recognising objects and events as members of particular sets and allocating names to them. Classification and identification both involve learners in identifying features, tests or procedures that discriminate between the things or processes being studied.

<table>
<thead>
<tr>
<th>Learner profile</th>
<th>Title of enquiry</th>
</tr>
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<tbody>
<tr>
<td>David KS2 L3</td>
<td>Is any of the litter attracted to a magnet?</td>
</tr>
<tr>
<td>Mia KS2 L4</td>
<td>Fact or opinion?</td>
</tr>
<tr>
<td>Sian KS2 L5</td>
<td>Vertebrate groups</td>
</tr>
<tr>
<td>Amy KS3 L6</td>
<td>Solids, liquids, gases and their particles</td>
</tr>
<tr>
<td>Ben KS3 L7</td>
<td>Is <em>Euglena</em> a plant or an animal? Explain</td>
</tr>
</tbody>
</table>

(d) Making things (or developing systems)

Enquiries that involve making things are often technological in nature and involve learners in designing an artefact or system to meet a human need. Those that require the use of scientific skills, knowledge and understanding can be classified in this way.

<table>
<thead>
<tr>
<th>Learner profile</th>
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</tr>
</thead>
<tbody>
<tr>
<td>David KS2 L3</td>
<td>Shadow puppets</td>
</tr>
<tr>
<td>David KS2 L3</td>
<td>Designing packaging for biscuits</td>
</tr>
<tr>
<td>Mia KS2 L4</td>
<td>Planet presentation</td>
</tr>
<tr>
<td>Tom KS2 L5</td>
<td>Map of the solar system</td>
</tr>
<tr>
<td>Tom KS2 L5</td>
<td>How can you make a model of a lighthouse?</td>
</tr>
<tr>
<td>Sian KS3 L5</td>
<td>Imaginary animal</td>
</tr>
<tr>
<td>Sian KS3 L5</td>
<td>How can we clean pond water?</td>
</tr>
<tr>
<td>Sian KS3 L5</td>
<td>How could people in an economically developing</td>
</tr>
<tr>
<td>Sian KS3 L5</td>
<td>Energy resources</td>
</tr>
<tr>
<td>Amy KS3 L6</td>
<td>Insulin presentation</td>
</tr>
<tr>
<td>Amy KS3 L6</td>
<td>Limestone enquiry</td>
</tr>
<tr>
<td>Amy KS3 L6</td>
<td>Volcanoes</td>
</tr>
</tbody>
</table>
(e) Fair testing

This is concerned with observing and exploring the relationship between an independent variable and a dependent variable. Independent variables are identified and one is manipulated while the others are controlled.

<table>
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<th>Learner profile</th>
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<tbody>
<tr>
<td>David KS2 L3</td>
<td>Which is the best material for stopping biscuits becoming soggy?</td>
</tr>
<tr>
<td>Mia KS2 L4</td>
<td>Making rockets</td>
</tr>
<tr>
<td>Mia KS2 L4</td>
<td>Does the mixture of lava affect the eruption of a volcano?</td>
</tr>
<tr>
<td>Tom KS2 L5</td>
<td>How can the brightness of a bulb in a circuit be changed?</td>
</tr>
<tr>
<td>Sian KS3 L5</td>
<td>How does the surface area affect the rate of evaporation?</td>
</tr>
<tr>
<td>Amy KS3 L6</td>
<td>How does caffeine affect the heart rate?</td>
</tr>
<tr>
<td>Ben KS3 L7</td>
<td>How does the mass of magnesium added affect the temperature rise in its reaction with copper sulphate?</td>
</tr>
</tbody>
</table>

(f) Using and applying models

Here learners use, apply or develop a model to test an idea or a theory.

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Tom KS2 L5</td>
<td>Mission Possible?</td>
</tr>
<tr>
<td>Tom KS2 L5</td>
<td>How can you make a model of a lighthouse?</td>
</tr>
<tr>
<td>Sian KS2 L5</td>
<td>How does the surface area affect the rate of evaporation?</td>
</tr>
<tr>
<td>Amy KS3 L6</td>
<td>Fairground ride</td>
</tr>
<tr>
<td>Ben KS3 L7</td>
<td>Historical reactions</td>
</tr>
<tr>
<td>Ben KS3 L7</td>
<td>How does a space shuttle land?</td>
</tr>
<tr>
<td>Ben KS3 L7</td>
<td>Can you work out work done?</td>
</tr>
</tbody>
</table>
There are three main areas of the Range at Key Stages 2 and 3. Each area has an overarching statement which gives the ‘big picture’ to guide teachers towards relevant learning opportunities.

<table>
<thead>
<tr>
<th>Area of the Range</th>
<th>Key Stage 2</th>
<th>Key Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interdependence of organisms</td>
<td>Pupils should use and develop their skills, knowledge and understanding by investigating how animals and plants are independent yet rely on each other for survival.</td>
<td>Pupils should use and develop their skills, knowledge and understanding by investigating how humans are independent yet rely on other organisms for survival, applying this to life in countries with different levels of economic development.</td>
</tr>
<tr>
<td>The sustainable Earth</td>
<td>Pupils should use and develop their skills, knowledge and understanding by comparing the Earth with other planets, investigating the materials around them and considering the importance of recycling.</td>
<td>Pupils should use and develop their skills, knowledge and understanding by investigating the materials in the Earth and its atmosphere and how they can change, and apply this in contemporary contexts.</td>
</tr>
</tbody>
</table>
Area of the Range  
How things work

Key Stage 2  
Pupils should use and develop their skills, knowledge and understanding by investigating the science behind everyday things, e.g. toys, musical instruments and electrical devices, the way they are constructed and work.

Key Stage 3  
Pupils should use and develop their skills, knowledge and understanding by investigating the science involved in a range of contemporary devices/machines and evaluate different energy resources and possibilities.

These ‘big picture’ statements should help teachers to plan to make links across the Range and between science and other curricular areas. In this way they give greater opportunity for more thematic based learning and teaching so that learners can link their thoughts more easily and transfer generic skills across subject boundaries.

The revised science order has been reduced so that teachers can allow learners time to construct their learning. The reduction in the number of attainment targets and the generalisation of statements also allows for a variety of links to be made between the traditional science areas. Ben’s task interrogating Joseph Priestley’s findings (Key Stage 3, Level 7) gives opportunities for links between combustion and photosynthesis. Similarly the ‘Moon Crash Landing 2020’ activity (Key Stage 2, Level 5) requires Tom to use knowledge and understanding from across the Range. Examples of cross-curricular activities can be found within the profiles, for example, Amy’s ‘Volcanoes’ activity (Key Stage 3, Level 6) links with geography, whilst David’s ‘Shadow puppets’ task (Key Stage 3, Level 3) links with design and technology.
Section 2

Expectations and progression in science
This section is designed to establish a common understanding of the standards associated with Levels 3 to 7 in the context of the programmes of study for Key Stages 2 and 3, although the profiles only evidence some of the level characteristics for Levels 2 to 8.

The level descriptions for science are set out in one attainment target. They show broad lines of progression in Skills in science, including Communication and Enquiry, across the Range of the programme of study. The level descriptions have been revised to reflect changes in the programme of study. The pitch and challenge remain broadly the same.

The level descriptions table found on the composite table on the Welsh Assembly Government website and in the order are written in a linear manner. However, learning is not linear. It is a cyclical spiral, with the need for pupils to revisit previously learned skills, knowledge and understanding so that they can consolidate and make further progress in their learning.

**Level characteristics**

The processes of planning, developing and reflecting are essential when carrying out scientific enquiries. To mirror this, the level descriptions are written as three paragraphs, relating to these processes, which are described in the developing thinking section of the skills framework. Communication, number and ICT skills are also subsumed. To help teachers to plan for and to review progress in science each process has been split into strands. The tables on the following pages show the level characteristics for each of the strands in planning, developing and reflecting. These should not be seen as ‘tick lists’ of attainment but should be used to plan for progress and to standardise teachers’ ideas of the characteristics of a level description. Some strands do not cover the whole spectrum of level descriptions. Where they do not cover the higher levels, pupils’ progress can only be assessed if they are given a more complex, abstract task that requires them to review the ‘big picture’ and/or one that is set in an unfamiliar context. *Embolden text* in these tables shows which level characteristics are exemplified by the pupil in the stated enquiry.

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3 [www.wales.gov.uk/educationandskills](http://www.wales.gov.uk/educationandskills) (see ‘Curriculum and assessment’ section)
It is necessary to use planning, developing and reflecting flexibly rather than as a specific way of teaching. Each process is inter-linked with the other two so for example, in order to plan an inquiry it is always necessary to reflect on prior learning.

Each level description builds on the previous one and therefore text from previous descriptions is not repeated as the strand is revisited in the next level, i.e. level descriptions are cumulative. Recognising level characteristics is an aid to assessing both formatively and summatively. Many of the teachers involved in developing this guidance kept field notes to remind them of pupils’ progress in science. Rather than trying to assess all pupils in a class at the same time, they either concentrated on specific groups of pupils, or on individuals.

Planning in science

To ensure success in a scientific inquiry pupils need to plan what they are going to do and how they are going to do it. Initially pupils will use everyday knowledge and understanding to plan. As they progress, they will use more scientific knowledge and understanding and this knowledge will become more abstract in nature as they progress further. In addition, pupils that initially required support from a teacher to plan an inquiry will become more independent as they progress. The plans produced by pupils become more methodical and eventually systematic in nature as they practice and refine their planning skills.

In order to plan a scientific inquiry, pupils need to activate prior skills, knowledge and understanding. So they need to think about what they already know and understand and the skills they have. They may then need to supplement these by finding evidence, information and ideas. In the profiles the evidence, information and ideas used by pupils are from many different sources, such as peers, teachers, internet searches, leaflets and books.
<table>
<thead>
<tr>
<th>Level characteristics in finding evidence, information and ideas</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. listen and respond to scientific ideas and react appropriately</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. choose from given options where to find evidence, information and ideas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. suggest where to find evidence, information and ideas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Shadow puppets’ (Key Stage 2, Level 3)</td>
<td>David suggests and then looks at a website for ideas as to how to make a shadow puppet.</td>
<td></td>
</tr>
<tr>
<td>‘Planet presentation’ (Key Stage 2, Level 4)</td>
<td>Mia looks at a website and a leaflet to find information on Saturn. However, some of the information she then uses is questionable as to its scientific relevance.</td>
<td></td>
</tr>
<tr>
<td>4. find and use a variety of evidence, information and ideas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Vertebrate groups’ (Key Stage 3, Level 5)</td>
<td>Sian looks on the internet in order to draw up her table to compare vertebrate groups. She only uses relevant information and inserts pictures to exemplify her findings.</td>
<td></td>
</tr>
</tbody>
</table>
Predicting

For successful planning pupils need to think about the possible outcomes. They need to address the question ‘What will happen if . . . ?’ in order to predict. Predictions can take many forms, for example, when asked to design or invent an organism or artefact, pupils will use predictive thinking to make decisions. In the profiles, Sian (Key Stage 3, Level 5) invents an ‘Imaginary animal’ and uses scientific knowledge and understanding to think about ‘What would happen if . . . ?’ in order to develop her design.

<table>
<thead>
<tr>
<th>Level characteristics in predicting</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3</strong> talk about their ideas and using their everyday experience they make simple predictions</td>
<td>‘Which is the best material for stopping biscuits becoming soggy?’ (Key Stage 2, Level 3)</td>
<td>David uses his everyday experiences to predict that plastic will be the most waterproof material as it’s commonly used for drink bottles.</td>
</tr>
<tr>
<td><strong>4</strong> use scientific knowledge and skills to…predict outcomes</td>
<td>‘Does the mixture of lava affect the eruption of a volcano?’ (Key Stage 2, Level 4)</td>
<td>Mia uses some scientific knowledge to predict that the reaction between vinegar and bicarbonate of soda will be ‘bigger’ when she uses more vinegar.</td>
</tr>
<tr>
<td><strong>5</strong> making predictions based on scientific knowledge and understanding, including simple models</td>
<td>‘How does the surface area affect the rate of evaporation?’ (Key Stage 3, Level 5)</td>
<td>Sian predicts that the greater the surface area the faster the rate of evaporation will be. She supports this with scientific knowledge that includes a simple model of change of state.</td>
</tr>
</tbody>
</table>
When planning a scientific enquiry, pupils need to think about how they are going to carry out their enquiry. They need to decide on the method or strategy that is going to be used. **Methods** that pupils suggest tend to be from past experiences. Many pupils find it helpful to use a writing frame to organise their thoughts when planning. Any writing frame that does not assist with the scientific knowledge and understanding required for an enquiry will not reduce a pupil’s possible attainment. Several examples of such writing frames are given in the profiles.

<table>
<thead>
<tr>
<th>Level characteristics in predicting</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6</strong> make predictions using abstract scientific ideas</td>
<td>‘How does caffeine affect the heart rate?’ Amy (Key Stage 3, Level 6)</td>
<td>Amy uses abstract scientific knowledge of how caffeine affects the body in order to predict what will happen to her heart rate.</td>
</tr>
<tr>
<td><strong>7</strong> make qualitative predictions using linked scientific knowledge and understanding gained from a variety of sources</td>
<td>‘How does the mass of magnesium added affect the temperature rise in its reaction with copper sulphate?’ (Key Stage 3, Level 7)</td>
<td>Ben links his knowledge of displacement and exothermic reactions to make predictions as to the outcome of his enquiry. His knowledge is from past work and the teacher’s demonstration.</td>
</tr>
<tr>
<td><strong>8</strong> make quantitative predictions, where appropriate, using detailed scientific knowledge and abstract ideas</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EP</strong> justify their predictions by making multiple links between scientific models, theories and systems</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Learning/thinking strategies are important to ensure that learning in science is consolidated. Pupils will initially suggest simple ideas, such as ‘discussing with a partner’ to sort out thoughts or ‘looking on the internet’ for information. Underpinning these are the strategies. For example there is no point discussing if you don’t listen. Similarly to search on the internet for information a pupil will need a strategy to decide which key words to use. By making these strategies explicit pupils will more easily be able to transfer them to another context whether in science or in other subjects. A writing frame used to organise the planning of a scientific enquiry, as discussed earlier is actually a learning/thinking tool.

<table>
<thead>
<tr>
<th>Level characteristics in methods and strategies</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 take part in simple activities and through a variety of experiences explore the world around them</td>
<td>‘Which is the best material for stopping biscuits becoming soggy?’ (Key Stage 2, Level 3)</td>
<td>David is supported by his teacher in planning the method for this fair test enquiry. However, his planning to control variables actually shows features of Level 4.</td>
</tr>
<tr>
<td>2 talk about the steps needed to carry out their enquiries</td>
<td>‘Does the mixture of lava affect the eruption of a volcano?’ (Key Stage 2, Level 4)</td>
<td>Mia bases her plan on her scientific knowledge of the reaction between vinegar and bicarbonate of soda. However, she does not state the quantities of any of the variables.</td>
</tr>
<tr>
<td>3 plan, with support, the method to be used for their enquiries</td>
<td>‘How does the surface area affect the rate of evaporation?’ (Key Stage 3, Level 5)</td>
<td>Sian’s plan is written in a systematic manner. She does state the volume of water she will use, although how she will use the hairdryer is vague.</td>
</tr>
<tr>
<td>4 use scientific knowledge and skills to plan their enquiries</td>
<td>‘Which is the best material for stopping biscuits becoming soggy?’ (Key Stage 2, Level 3)</td>
<td>David is supported by his teacher in planning the method for this fair test enquiry. However, his planning to control variables actually shows features of Level 4.</td>
</tr>
<tr>
<td>5 systematically plan their enquiries</td>
<td>‘Does the mixture of lava affect the eruption of a volcano?’ (Key Stage 2, Level 4)</td>
<td>Mia bases her plan on her scientific knowledge of the reaction between vinegar and bicarbonate of soda. However, she does not state the quantities of any of the variables.</td>
</tr>
<tr>
<td>Level characteristics in methods and strategies</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
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</tr>
<tr>
<td><strong>6</strong> suggest a variety of methods or strategies for their enquiries</td>
<td>Amy’s profile (Key Stage 3, Level 6)</td>
<td>Across Amy’s profile she suggests different scientific methods for tackling her enquiries.</td>
</tr>
<tr>
<td><strong>7</strong> give some justification for the methods and strategies they plan to use</td>
<td>‘Respiration and combustion’ (Key Stage 3, Level 7)</td>
<td>Ben suggests and gives some justification for using a Venn diagram to organise his thoughts.</td>
</tr>
<tr>
<td><strong>8</strong> justify their methods and strategies in view of the reliability of the information and/or the data to be gathered and the accuracy of the equipment to be used</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EP</strong> justify their methods and strategies making multiple links to prior learning and independent research and taking account of possible problems</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Fair testing**  

*Fair testing* enquiries require detailed, systematic planning to ensure that the outcomes are scientifically reliable. Pupils working at lower levels will struggle to fulfil these requirements.

<table>
<thead>
<tr>
<th>Level characteristics in fair testing</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4</strong> recognise, with support, the variables to change and measure and those to be kept the same</td>
<td>‘Making rockets’ (Key Stage 2, Level 4)</td>
<td>Questioning by the teacher helps Mia clarify her thoughts as to the key variables.</td>
</tr>
<tr>
<td><strong>5</strong> identify key variables and distinguish between independent and dependent variables and those that they will keep the same</td>
<td>‘How can the brightness of a bulb in a circuit be changed?’ (Key Stage 2, Level 5)</td>
<td>Tom independently notes the key variables of number of batteries (independent) and the brightness of the bulb (dependent). He also recognises that he needs to control any extraneous light.</td>
</tr>
<tr>
<td><strong>6</strong> plan how to control the variables that they need to keep the same and make decisions about the range and values of the independent variable</td>
<td>‘How does caffeine affect the heart rate?’ (Key Stage 3, Level 6)</td>
<td>In her plan, Amy lists the key variables and makes notes as to how they can be controlled. She couldn’t make decisions about the range and values of the independent variable as this was set by the mass of caffeine in the drink.</td>
</tr>
<tr>
<td><strong>7</strong> identify key variables that may not be readily controlled explaining why this is the case</td>
<td>‘How does the mass of magnesium added affect the temperature rise in its reaction with copper sulphate?’ (Key Stage 3, Level 7)</td>
<td>Ben recognises that he cannot control the surface area of magnesium metal used. He explains why he can’t control it and then how this could affect his findings.</td>
</tr>
<tr>
<td><strong>8</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EP</strong> plan to track changes in more than one dependent variable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Determining success criteria

Any scientific enquiry could start by pupils thinking about what success in the task may look like. However, asking pupils to determine success criteria for every task would demotivate them. It is very difficult for most pupils to determine success criteria without first modelling success. The activity ‘What makes a good investigation?’ in Sian’s profile (Key Stage 3, Level 5) is an example of modelling investigation write-ups to enable Sian to suggest success criteria for the write-up of her own investigation.

<table>
<thead>
<tr>
<th>Level characteristics in determining success criteria</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 talk about…what is needed to be successful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 agree on some basic success criteria</td>
<td>‘Designing packaging for biscuits’ (Key Stage 2, Level 3)</td>
<td>David and his partner agree on the simple success criteria for the design of stopping the biscuits from becoming soggy, looking good and using a material that could be recycled.</td>
</tr>
<tr>
<td>4 decide upon some basic success criteria</td>
<td>‘Planet presentation’ (Key Stage 2, Level 4)</td>
<td>Mia decides on her own success criteria for her presentation and although they are basic they are her own ideas.</td>
</tr>
<tr>
<td>5 give some justification for their success criteria</td>
<td>‘How can you make a model of a lighthouse?’ (Key Stage 2, Level 5)</td>
<td>Tom decides that his model lighthouse needs to have a working light that can be turned on and off and his model needs to be high from the ground. He justifies the latter by explaining that the light could be seen from further away.</td>
</tr>
<tr>
<td>6 justify their success criteria</td>
<td>‘Insulin presentation’ (Key Stage 3, Level 6)</td>
<td>Amy verbally justifies her suggested success criteria for the presentation.</td>
</tr>
</tbody>
</table>
Developing in science

Developing an enquiry is the actual carrying out of a method/strategy and the processing of the findings. Once pupils have planned they need to carry out their enquiry in order to gather their findings. The term ‘findings’ used in this context includes a wide variety of evidence, information, data or ideas. It does not just refer to the findings of a scientific investigation in the traditional sense. Pupils will develop many different types of scientific enquiry in their science career. Some enquiries will be more investigative in nature while others will be developing their own ideas.

In most scientific enquiry types pupils are asked to either observe or measure. As pupils progress they do this in a more systematic way. At the lower levels pupils measure using non-standard measures such as teaspoonfuls, progressing to standard measures using S.I. units. At higher levels pupils measure accurately, which relies on the selection of the necessary measuring equipment with the most useful and appropriate divisions.

<table>
<thead>
<tr>
<th>Level characteristics in observing and measuring</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 <em>observe…simple features of organisms, objects, materials and events</em></td>
<td>‘Comparing two environments’ (Key Stage 2, Level 3)</td>
<td>David compares the organisms found in a field and in a hedgerow. He sorts them using a Venn diagram provided by the teacher.</td>
</tr>
<tr>
<td>2 <em>make enough observations to be able to sort, group and compare organisms, objects, materials and events</em></td>
<td>‘Comparing two environments’ (Key Stage 2, Level 3)</td>
<td>David follows his teacher’s instructions in order to compare the organisms in each environment.</td>
</tr>
<tr>
<td>3 <em>follow a simple series of instructions safely to gather their findings</em></td>
<td>‘Which is the best material for stopping biscuits becoming soggy?’ (Key Stage 2, Level 3)</td>
<td>David could have measured the mass of water absorbed by the biscuits but chose instead to observe the outcomes.</td>
</tr>
<tr>
<td>Level characteristics in observing and measuring</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>--------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>4</strong> follow the planned method make qualitative observations and... use standard measuring equipment to make measurements within a given range using S.I. units</td>
<td>‘Does the mixture of lava affect the eruption of a volcano?’ (Key Stage 2, Level 4)</td>
<td>Mia followed her plan. She made detailed observations of the different ‘volcanic’ eruptions.</td>
</tr>
<tr>
<td></td>
<td>‘Making rockets’ (Key Stage 2, Level 4)</td>
<td>Mia measured the distance her rockets travelled in cm.</td>
</tr>
<tr>
<td><strong>5</strong> select measuring instruments that allow them to make a series of accurate measurements</td>
<td>‘How does the surface area affect the rate of evaporation?’ (Key Stage 3, Level 5)</td>
<td>Sian selected a stopwatch (the most accurate instrument available) and used graph paper to measure the surface area of each container.</td>
</tr>
<tr>
<td><strong>6</strong> make precise observations and accurate measurements using equipment with fine divisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>7</strong> systematically observe and measure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
When pupils carry out a scientific enquiry, many of them monitor their progress. However, this is rarely explicit either in written or verbal responses. By making the monitoring process more explicit it is hoped that pupils will take more responsibility for their on-going decisions and therefore their outcomes will be more meaningful to them.

<table>
<thead>
<tr>
<th>Level characteristics in monitoring progress</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td>making amendments where necessary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 regularly check progress and revise the method where necessary</td>
<td>‘How can you make a model of a lighthouse?’ (Key Stage 2, Level 5)</td>
<td>Tom built several versions of circuits with differently constructed switches until he was happy that the circuit would work once placed in his structure.</td>
</tr>
<tr>
<td>6 regularly check progress, make ongoing revisions when necessary and begin to justify any amendments or improvements made</td>
<td>‘How does caffeine affect the heart rate?’ (Key Stage 3, Level 6)</td>
<td>Amy made an ongoing revision to the method once she recognised that her heart rate was remaining high, past the time they had allocated to take the pulse rate and she simply justified this.</td>
</tr>
<tr>
<td>7 justify any amendments made to the method/strategy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Communicating findings

In all scientific enquiries, pupils are expected to communicate their findings. Communication in science can take many forms and increasingly involves the use of number skills as pupils progress. However, the emphasis in these profiles is on the written word due to the nature of the guidance. As they progress pupils display their findings in a more scientific and systematic way as they understand and use the conventions of table and chart/graph drawing.

<table>
<thead>
<tr>
<th>Level characteristics in communicating findings</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 describe simple features of organisms, objects, materials and events through talking, drawing, mark-making or writing simple words</td>
<td>‘Litter survey’ (Key Stage 2, Level 3)</td>
<td>David draws a tally chart to show his findings when comparing the materials that litter is made from.</td>
</tr>
<tr>
<td>2 make simple records of their findings by talking, drawing, writing simple sentences, constructing tally charts or pictograms</td>
<td>‘Litter survey’ (Key Stage 2, Level 3)</td>
<td>David draws a bar chart of the class findings of the materials that the litter is made from using axes and scales given to him by the teacher.</td>
</tr>
<tr>
<td>3 begin to organise their findings and display them in a given format</td>
<td>‘The rocket launch’ (Key Stage 2, Level 4)</td>
<td>Mia uses relevant scientific language in her description and explanation, although her work contains confused scientific ideas.</td>
</tr>
<tr>
<td>4 organise and communicate their findings using relevant scientific language display these in tables, bar charts and in simple line graphs when the axes and scales are given</td>
<td>‘Making rockets’ (Key Stage 2, Level 4)</td>
<td>Mia independently draws a table to show her findings. She also draws a line graph using axes and scales given to her by the teacher.</td>
</tr>
<tr>
<td>Level characteristics in communicating findings</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>------------------------------------------------</td>
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</tr>
<tr>
<td><strong>5</strong> organise and communicate their findings integrating different forms in various presentations and record these systematically using S.I. units where appropriate</td>
<td>‘Vertebrate groups’ (Key Stage 3, Level 5)</td>
<td>Sian uses text and images in her table.</td>
</tr>
<tr>
<td></td>
<td>‘How does the surface area affect the rate of evaporation?’ (Key Stage 3, Level 5)</td>
<td>Sian records her findings using S.I units.</td>
</tr>
<tr>
<td></td>
<td>‘How can the brightness of a bulb in a circuit be changed?’ (Key Stage 2, Level 5)</td>
<td>Tom explains that his results should be drawn as a bar chart as the independent variable, the number of batteries, is discontinuous.</td>
</tr>
<tr>
<td></td>
<td>uses a line graph to describe relationships between two continuous variables</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>6</strong> organise and communicate their findings in a variety of ways fit for purpose and audience</td>
<td>‘Limestone enquiry’ (Key Stage 3, Level 6)</td>
</tr>
<tr>
<td></td>
<td>use appropriate axes and scales for graphs to show data effectively</td>
<td>‘How does caffeine affect the heart rate?’ (Key Stage 3, Level 6)</td>
</tr>
<tr>
<td></td>
<td>begin to use some quantitative definitions</td>
<td>‘Volcanoes’ (Key Stage 3, Level 6)</td>
</tr>
</tbody>
</table>
### Level characteristics in communicating findings

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7</strong></td>
<td><em>draw lines of best fit on graphs</em>&lt;br&gt;<em>use some quantitative definitions and perform calculations using the correct units</em></td>
<td>‘Can you work out work done?’&lt;br&gt;(Key Stage 3, Level 7)</td>
<td>Ben uses the equation for work done to calculate and then order a list of situations. He uses the correct units.</td>
</tr>
</tbody>
</table>

### 8

**EP** *develop an organised system to record findings clearly conveying points of interest*

### Reviewing findings

Once pupils have their findings from a scientific enquiry it is important that they recognise whether there is a pattern in them in order to conclude. However, **findings need to be reviewed** and questioned as to whether they can be trusted or not. In a simple way, repeating measurements or tests or finding more information that agrees with the original findings leads pupils to consider reliability. However, the spotting of an anomaly in a pattern, whether it is in readings or information, should lead pupils working at higher levels to question why this is the case and suggest explanations for it. Evidence, information and ideas can be biased therefore pupils need to think about the nature and origin of the sources they have used. At the highest levels pupils also consider the validity of their findings. This usually will require them to think whether their findings could be transferred to a different enquiry or situation.

<table>
<thead>
<tr>
<th>Level characteristics in reviewing findings</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3</strong> <em>begin to identify simple patterns and trends</em>&lt;br&gt;<em>begin to distinguish between scientific ‘facts’, beliefs and opinions</em></td>
<td>‘Litter survey’&lt;br&gt;(Key Stage 2, Level 3)&lt;br&gt;‘Fact or opinion?’&lt;br&gt;(Key Stage 2, Level 4)</td>
<td>David recognises that most of the litter is made from plastic by using his bar chart.&lt;br&gt;Mia is starting to think about ‘facts’ and opinions and the differences between the way they are written.</td>
</tr>
<tr>
<td>Level characteristics in reviewing findings</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td><strong>4</strong> identify patterns and trends</td>
<td>‘How can a guitar make a sound?’ (Key Stage 2, Level 4)</td>
<td>Mia reviews her observations and recognises that the thicker strings make a deep sound when plucked.</td>
</tr>
<tr>
<td>distinguish between ‘facts’, beliefs and opinions and begin to recognise bias</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5</strong> use line graphs to describe relationships between two continuous variables identify bias and start to consider reliability</td>
<td>‘How does the surface area affect the rate of evaporation?’ (Key Stage 3, Level 5)</td>
<td>Mia uses her line graph to describe that the larger the surface area the faster the water evaporated. In her suggestions for improvement she recognises the need to repeat her experiment to check her results.</td>
</tr>
<tr>
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</tr>
<tr>
<td><strong>6</strong> assess bias, consider reliability offer some explanations for any anomalies</td>
<td>‘Questioning an image of the solar system’ (Key Stage 2, Level 5)</td>
<td>Tom checks the authenticity of the image he has been provided with and offers some explanations for the anomalies the image has suggested.</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td><strong>7</strong> begin to evaluate their findings in order to gauge bias, reliability and validity</td>
<td>‘Can you work out work done?’ (Key Stage 3, Level 7)</td>
<td>Ben makes notes about the sources he has used to gather the data. Within these notes he questions their possible bias, reliability and validity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>8</strong> evaluate their findings in order to gauge bias, reliability and validity identify and explore uncertainties and explain anomalies</td>
<td></td>
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</tr>
</tbody>
</table>
Pupils working at the lower levels are more able to describe their findings rather than explain them. Comparing in order to group requires pupils to look at similarities and differences. Pupils working at Level 2 and above can describe the basis for their groupings and as such are explaining their decisions based on what they can see, feel or hear. Simple explanations of the findings from a scientific enquiry such as those based on pupils’ everyday experiences usually take the form of ‘This happened because ...’. In addition pupils working at Level 3 can give similar explanations for differences and changes. The use of scientific knowledge and understanding to explain their findings, differences or changes starts at Level 4 and becomes more detailed and abstract in nature as learners progress. Pupils working at Level 5 and above will use simple models to explain. Simple models usually involve more concrete ideas, such as explaining changes of state using the ideas of solids, liquids and gases without discussing what is actually happening to the particles. Pupils working at Level 6 and above understand abstract models such as particle theory and as they progress they apply these models to their explanations. It may be that pupils working below Level 6 try to use abstract ideas of particles in their explanations but do so incorrectly. Pupils working at Level 7 and above link processes and/or systems in their explanations. At times these processes/systems will be from different sections of the Range.

In reality, this strand sets the context and therefore challenge of the level description. It is a direct link to the Range and should be used when planning future learning to achieve progression.

<table>
<thead>
<tr>
<th>Level characteristics in explaining</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. recognise and name a range of common organisms, objects, materials, light sources and sound sources</td>
<td>‘Litter survey’ (Key Stage 2, Level 3)</td>
<td>David describes why he has grouped the litter into his categories. He struggles to group some of the materials of the litter as they don’t quite fit into his categories.</td>
</tr>
<tr>
<td>Level characteristics in explaining</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3</td>
<td>‘Comparing two environments’ (Key Stage 2, Level 3)</td>
<td>David explains why there is more plastic in the litter by relating it to the quantities of pop and crisps he and his peers drink and eat.</td>
</tr>
<tr>
<td>give an explanation, based upon their everyday experiences, for their findings, including any patterns</td>
<td>‘Shadow puppets’ (Key Stage 2, Level 3)</td>
<td>David recognises that light cannot pass through solid objects and so a shadow is formed.</td>
</tr>
<tr>
<td>give simple explanations for differences between and changes to organisms, objects, materials and physical phenomena</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>‘Making rockets’ (Key Stage 2, Level 4)</td>
<td>Mia tries to use her science knowledge to explain why her rockets travel different distances. She relates the movement of the rockets (the force) to the air expelled.</td>
</tr>
<tr>
<td>use some scientific knowledge and understanding to explain their findings and differences between, or changes to organisms, materials and physical phenomena</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>‘How could people in an economically developing country get clean water?’ (Key Stage 3, Level 5)</td>
<td>Sian uses a simple model of change of state to explain why her model of cleaning water would work. She shows the processes of evaporation and condensation and states that any impurities will remain in the pond.</td>
</tr>
<tr>
<td>Level characteristics in explaining</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>-------------------------------------</td>
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<td>-----------------------------</td>
</tr>
<tr>
<td>6 use abstract scientific knowledge and understanding, including models, when explaining their findings and differences between, or changes to, organisms, materials and physical phenomena recognise that a number of factors and/or processes may have to be considered when explaining changes</td>
<td>‘Melting Ice’ (Key Stage 3, Level 6)</td>
<td>In her verbal presentation to the class Amy uses the particle model to explain change of state. She describes how heat energy would affect the movement of the particles. Had she discussed in more detail how the forces between the particles were affected her response would be more characteristic of Level 7.</td>
</tr>
<tr>
<td></td>
<td>‘Fairground ride’ (Key Stage 3, Level 6)</td>
<td>Amy shows in her diagram that she is considering energy changes and work done to explain changes in her fictitious ride. She is starting to link abstract ideas and had this been more evident, her response would be more characteristic of Level 7.</td>
</tr>
<tr>
<td>Level characteristics in explaining</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>-------------------------------------</td>
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<td>-------------------------------</td>
</tr>
</tbody>
</table>
| **7**  
explain to what extent their findings are consistent with scientific knowledge and understanding, using abstract ideas at times  
in explanations  
they apply abstract ideas and make links between processes  
or systems  
begin to use their explanations to make predictions  

*Example in profile*  
‘Historical reactions’  
(Key Stage 3, Level 7)  

*What the pupil actually does*  
Ben makes links between combustion and photosynthesis when he explains Joseph Priestley’s experiment. He goes on to use these explanations to make predictions relating to fossil fuels and the greenhouse effect. |
| **8**  
explain to what extent their findings are consistent with abstract scientific ideas  
explain the impact of one system on another  

*Example in profile*  

*What the pupil actually does*  

| **EP**  
use complex, abstract ideas or combinations of models/systems to explain their findings  
use their knowledge and understanding to critically evaluate predicted effects on systems  

*Example in profile*  

*What the pupil actually does*  


In order to **draw conclusions** or to **make decisions**, pupils need to review and explain their findings, whether this be data, ideas or information. Initially pupils will just state what they have found out from their scientific enquiry and make their own decisions. As they progress, their conclusions are increasingly related to their findings and their opinions or decisions are backed by further information. Part of collecting further information requires collaborative working so that pupils listen to others’ views and opinions. At the higher levels pupils question their conclusions and opinions as to their scientific validity and discuss this by referring to further scientific evidence.

### Level characteristics in drawing conclusions and making decisions

<table>
<thead>
<tr>
<th>Level characteristics</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3</strong></td>
<td><strong>say what they have found out from their work and make their own decisions by weighing up pros and cons</strong></td>
<td>Is any of the litter attracted to a magnet? (Key Stage 2, Level 3)</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td><strong>begin to draw conclusions, form considered opinions</strong></td>
<td>‘Making rockets’ (Key Stage 2, Level 4)</td>
</tr>
<tr>
<td></td>
<td><strong>make informed decisions</strong></td>
<td>‘How can a guitar make a sound?’ (Key Stage 2, Level 4)</td>
</tr>
<tr>
<td>Level characteristics in drawing conclusions and making decisions</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
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<td>-------------------------------</td>
</tr>
</tbody>
</table>
| 5  
**draw conclusions that are consistent with the findings** | ‘How can the brightness of a bulb in a circuit be changed?’ (Key Stage 2, Level 5) | Tom draws a conclusion that describes the relationship between the variables of number of batteries and the brightness of the bulb. |
|  | ‘How can we clean pond water?’ (Key Stage 3, Level 5) | Sian works collaboratively throughout her profile and this is especially evident as she monitors progress in this enquiry. |
| 6  
**consider others’ views to inform opinions and decisions** | ‘Insulin presentation’ (Key Stage 3, Level 6) | Amy considers information from a wide range of sources from differing perspectives to write the presentation. |
| 7  
**consider a wider range of perspectives to inform opinions and decisions** | ‘Can you work out work done?’ (Key Stage 3, Level 7) | Ben recognises the need to check the validity but doesn’t actually describe how he might do this. |
| 8  
**describe how they might collect more information in order to check the validity of their conclusions** |  |  |
| **EP**  
**draw conclusions showing an awareness of the degree of uncertainty and a range of views** |  |  |
| **use detailed evidence to form consistent conclusions/opinions** |  |  |
Reflecting in science

Reflecting on learning is an essential part of consolidating new scientific ideas and skills. It is not expected that reflection only happens at the end of the lesson. Reflection is an integral part of an entire lesson and as described earlier, reflecting on prior skills, knowledge and understanding is needed before a pupil can plan what they are going to do. Pupils working at the lower levels will struggle to reflect on their learning either generically or scientifically. They will tend to describe simply what they have done.

Once pupils can determine success criteria either informally or formally, they can decide whether their method was successful or otherwise. Reflecting on success therefore becomes more systematic and meaningful. It can lead to an increased emphasis on peer and self-assessment as well as to pupils setting their own targets for improvement.

### Reviewing success

<table>
<thead>
<tr>
<th>Level characteristics in reviewing success</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 respond to questions about what worked and what didn’t</td>
<td>‘Designing packaging for biscuits’ (Key Stage 2, Level 3)</td>
<td>David has linked his design to his success criteria.</td>
</tr>
<tr>
<td>3 link outcomes to success criteria and identify what worked and what didn’t</td>
<td>‘Shadow puppets’ (Key Stage 2, Level 3)</td>
<td>David begins to think about how the method could be improved.</td>
</tr>
<tr>
<td>4 decide whether their method was successful by referring to their success criteria say how they could improve it</td>
<td>‘Planet presentation’ (Key Stage 2, Level 4)</td>
<td>Mia refers to her basic success criteria in her brief evaluation. She suggests other information she could have used, about Jupiter’s moons, which in her opinion would have improved her presentation.</td>
</tr>
<tr>
<td>Level characteristics in reviewing success</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>--------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td><strong>5</strong> begin to evaluate how far success criteria fully reflect successful outcomes</td>
<td>‘How can you make a model of a lighthouse?’ (Key Stage 2, Level 5)</td>
<td>Tom recognises that his success criteria had flaws and realises how he could amend them.</td>
</tr>
<tr>
<td><strong>6</strong> evaluate how far success criteria fully reflect successful outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>7</strong> refine success criteria in the light of experience for future occasions</td>
<td>‘Respiration and combustion’ (Key Stage 3, Level 7)</td>
<td>Ben reflects on his free-response answer and suggests how he could change his success criteria to ensure better quality of work next time.</td>
</tr>
</tbody>
</table>
So that pupils can evaluate how they have learned they need to be comfortable with learning/thinking vocabulary in order to express themselves. Pupils working at the lower levels will use terms such as ‘talked’ or ‘looked in a book’ to give a more concrete feel to their learning. As they progress they use more abstract terms such as ‘analysed’ or ‘researched’. Using thinking tools helps pupils to clarify their learning/thinking processes. For example, David (Key Stage 2, Level 3) and Ben (Key Stage 3, Level 7) both use Venn diagrams to compare. Ben recognises the importance of using a Venn diagram and goes on to describe how he can refine this tool for future use.

<table>
<thead>
<tr>
<th>Level characteristics in evaluating own learning and thinking</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. describe how they have learned and identify the ways that worked the best</strong></td>
<td>‘How can a guitar make a sound?’ (Key Stage 2, Level 4)</td>
<td>Mia uses a metacognitive caterpillar tool to show how she has learned. She uses terms such as ‘talked’ and ‘wrote’. She also identifies that ‘talking’ was the best way and even goes on to justify her reasons.</td>
</tr>
<tr>
<td><strong>5. identify the learning/thinking strategy they have used</strong></td>
<td>‘How can we clean pond water?’ (Key Stage 3, Level 5)</td>
<td>Sian uses learning/thinking terms to describe what she had done. She identifies ‘brainstorming’ as a strategy she had used. Her other ideas sum up how she worked without getting to the ‘How I did this’, i.e. the strategies she used.</td>
</tr>
<tr>
<td><strong>6. identify the learning/thinking strategies being used</strong></td>
<td>‘Limestone enquiry’ (Key Stage 3, Level 6)</td>
<td>Amy clearly identifies a number of strategies she uses, such as ‘brainstorming’, ‘scanning’ and the tool of a ‘KWHL grid’.</td>
</tr>
<tr>
<td>Level characteristics in evaluating own learning and thinking</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>-------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>7 review their strategies in light of results obtained or the information gathered</td>
<td>‘Respiration and combustion’ (Key Stage 3, Level 7)</td>
<td>Ben reviews his strategy in light of his self-assessment by suggesting that he could use a three circled Venn diagram to compare these two processes with photosynthesis.</td>
</tr>
<tr>
<td>8 suggest alternative learning/thinking strategies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP evaluate the likely effectiveness of alternative strategies and refine learning/thinking strategies for future occasions</td>
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</tbody>
</table>

**Linking learning**

Pupils working at the lower levels may need to be asked questions in order to link what and how they have learned in science lessons, usually to more everyday contexts or vice versa. As pupils progress they link their learning to other science contexts and eventually make links to other subjects or life outside school with increasing confidence. At higher levels the links become more abstract in nature and are used to make predictions both within science and the wider world. Linking skills, knowledge and understanding in science ensures that learning is consolidated and remembered so that it can be applied in new situations.

Focused questioning is a vital tool in getting pupils to link ideas and methods. Questions such as ‘Why do you think that?’ or ‘Where did you get that idea from?’ will push pupils towards making links with what they can already do or what they know. To ensure pupils link what they have found out with other ideas, questions could be asked such as ‘Where have you come across this before?’ or ‘Where could you also use what you have done/found out?’.
<table>
<thead>
<tr>
<th>Level characteristics in linking learning</th>
<th>Example in profile</th>
<th>What the pupil actually does</th>
</tr>
</thead>
<tbody>
<tr>
<td>3  <em>link the learning, with support, to familiar situations</em></td>
<td>‘Designing packaging for biscuits’ (Key Stage 2, Level 3)</td>
<td>David is questioned by his teacher to help him to link his design with the materials that biscuits are actually packaged in as well as recycling.</td>
</tr>
<tr>
<td>4  <em>link the learning to similar situations</em></td>
<td>‘Does the mixture of lava affect the eruption of a volcano?’ (Key Stage 2, Level 4)</td>
<td>Mia links her findings from using a model volcanic eruption with what might actually happen in a real-life situation. Therefore she is linking ideas about two ‘volcanoes’.</td>
</tr>
<tr>
<td>5  <em>link the learning to dissimilar but familiar situations</em></td>
<td>‘How could people in an economically developing country get clean water?’ (Key Stage 3, Level 5)</td>
<td>Sian links her design of a water purifying model to the video clip about life in an economically developing country. In this case the video clip is classed as being familiar to her.</td>
</tr>
<tr>
<td>6  <em>link the learning to unfamiliar situations</em></td>
<td>‘Melting ice’ (Key Stage 3, Level 6)</td>
<td>Amy links her ideas on ice melting to the rate of ice caps melting due to global warming. The science behind the rate of ice caps melting is unfamiliar to her although she has some knowledge of the ice caps melting.</td>
</tr>
<tr>
<td>Level characteristics in linking learning</td>
<td>Example in profile</td>
<td>What the pupil actually does</td>
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<tr>
<td>---------------------------------------------</td>
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<td>-------------------------------</td>
</tr>
<tr>
<td>7 <em>link the learning to more abstract situations</em></td>
<td>‘Historical reactions’ (Key Stage 3, Level 7)</td>
<td>Ben links what he has learned about Joseph Priestley’s experiment with fossil fuels and the greenhouse effect.</td>
</tr>
<tr>
<td>8 <em>link learning to make further predictions</em></td>
<td></td>
<td>He goes on to make predictions about possible effects to life on Earth.</td>
</tr>
</tbody>
</table>
Section 3

Making judgements at the end of Key Stages 2 and 3
This section shows how level descriptions can be used when making judgements about which level best describes a learner’s overall performance at the end of Key Stages 2 and 3.

You may find the following points useful when considering the profiles in this section.

• The learner profiles are not presented as a model for how you should collect evidence about your learners. Although you will want to be able to explain why you have awarded a particular level to a learner at the end of the key stage, there is no requirement for judgements to be explained in this way or supported by detailed collections of evidence on each learner. Decisions about collecting evidence, and about its purpose and use, are matters for teachers working within an agreed school policy.

• The commentaries on the pieces of work have been written to explain the judgement made about a learner’s performance. They are not intended as an example of a report to parents/guardians.

• The materials in each learner profile can only represent a small part of the information and experiences that make up a teacher’s knowledge of each learner. They do not reflect the extent of the knowledge of each learner that you will have built up over time across a range of different contexts. You will use this knowledge to make a rounded judgement about the level that best fits each learner’s performance.

• You will arrive at judgements by taking into account strengths and weaknesses in performance across a range of contexts and over a period of time. Opportunities will need to be provided for learners to demonstrate attainment in all aspects of the level descriptions.

• Some of your learners may need to use a range of alternative forms of communication to show what they know, what they understand and what they can do.
Profiles

Key to activities in the learner profiles

Each activity has a reference box situated at the start of the activity. The box gives the title of the activity, the type of enquiry and references to the programme of study. The references attributed to each sample are what the learner actually does. Each activity has opportunities for learners to use other skills and at times apply these skills to other areas of the Range. The statements from the programme of study are then referenced with their respective numbers.

Skills

<table>
<thead>
<tr>
<th>C</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP</td>
<td>Enquiry planning</td>
</tr>
<tr>
<td>ED</td>
<td>Enquiry developing</td>
</tr>
<tr>
<td>ER</td>
<td>Enquiry reflecting</td>
</tr>
</tbody>
</table>

Range

<table>
<thead>
<tr>
<th>IO</th>
<th>Interdependence of organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSE</td>
<td>The sustainable Earth</td>
</tr>
<tr>
<td>HTW</td>
<td>How things work</td>
</tr>
</tbody>
</table>
David is an 11-year-old learner in Key Stage 2. His teacher knows much more about David’s performance than can be included here. However, this profile has been selected to illustrate characteristic features of David’s work across a range of activities. Each example is accompanied by a brief commentary to provide a context and indicate particular qualities in the work.

Much of his work is reported orally or in pictures. He receives some help with reading, writing and word processing from his teacher or a support assistant.

David’s teacher judges that his performance in science is best described as Level 3.

Within the theme of Sustainability, the class carried out a survey of the litter from their packed lunches. They looked at the material each piece of litter was made from. Pupils were asked to group the litter using their own criteria.

**Litter survey**
Pattern-seeking enquiry

**Skills**
C2; ED2, 4, 5, 7; ER3.

**Range**
IO7; TSE3, 6.

**Teacher:**
What can you see, David, that makes these two pieces of litter different to each other?

**David:**
One is a sweet packet and the other’s a pop bottle.

**Teacher:**
What is each one made of?

**David:**
That one’s paper and the other’s plastic.

**Teacher:**
Can you group the rest of the litter into those made of paper and those made of plastic?
David grouped the litter but left some pieces out of the groups. He made enough observations to group the litter, in this case into ‘paper’ and ‘plastic’. He then went on to make two further groups, one of ‘metal’ litter and one of ‘crisp packets’. The teacher asked him why he put the crisp packets together as a group. He said that it’s because some seem to be made of ‘paper and plastic’ while the others are shiny like metal. After a few minutes thinking he put the shiny crisp packets into the metal group but kept the others in a separate group; ‘paper and plastic’.

This is his tally chart:

<table>
<thead>
<tr>
<th></th>
<th>Paper</th>
<th>Plastic</th>
<th>Metal</th>
<th>Paper and Plastic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Observations</td>
<td>1</td>
<td>1</td>
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<td>1</td>
</tr>
<tr>
<td>Observations</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

In groups, pupils then discussed their criteria and findings to merge their tally charts. David was persuaded that the litter in his ‘paper and plastic’ group should go into the ‘plastic’ group.

The tally charts of the groups were merged and a class pictogram of the litter was drawn up collaboratively. Each pupil was then asked to draw a bar chart of the pictogram. The teacher gave David and other pupils working at a similar level an outline of the axes on squared paper for the bar chart. The rest of the class was asked just to use squared paper with no pre-drawn axes. David drew the bar chart in the given format.
The teacher questioned David as to what he had found out.

**David:**
The thing that most litter’s made out of is plastic.

**Teacher:**
Why do you think that most of the litter is made of plastic?

**David:**
Because we eat more pop and crisps than other foods.

**Teacher:**
Should we be doing this?

**David:**
No. Pop and crisps are bad for you.

David identified the simple pattern, said what he had found out and gave an explanation for the class findings based on his everyday experiences.
Work on recycling included testing litter to see if it was attracted by a magnet. David’s table of results is shown below. The teacher explained to the class the terms ‘magnetic’ and ‘non-magnetic’ before David was given the table format.

<table>
<thead>
<tr>
<th>litter</th>
<th>material</th>
<th>all magnetic?</th>
<th>some magnetic?</th>
<th>not magnetic?</th>
</tr>
</thead>
<tbody>
<tr>
<td>newspaper</td>
<td>paper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bottle</td>
<td>plastic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pop cans</td>
<td>metal</td>
<td>✅</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Teacher:  
What have you found out by doing this experiment?

David:  
We can use a magnet to sort out metals from litter.

Teacher:  
Could you use a magnet to pick out all the metals in litter.

David:  
Yes.

David’s next steps:  
Find out if all metals are magnetic. You might like to look at the website ‘Science is fun’ or use a magnet to test more metals in the classroom.

David completed the table and said that he found out from his work that all metals are magnetic. The latter is more of an everyday explanation of the differences between materials than a scientific one.
Which is the best material for stopping biscuits becoming soggy?

Fair testing enquiry

Skills
C2; EP2, 4, 5, 6; ED 1, 2, 4, 5.

Range
TSE4.

David planned his method with support and recorded his investigation on the sheet below. He made an oral prediction that plastic would be the most waterproof because bottles are made from plastic and used for drinks. David used his everyday experience to make a prediction.

<table>
<thead>
<tr>
<th>I changed the type of wrapping</th>
<th>I observed what happened to the biscuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thick plastic</td>
<td>Unchanged</td>
</tr>
<tr>
<td>Grease proof paper</td>
<td>Left around the side</td>
</tr>
<tr>
<td>cling Film</td>
<td>wet around the side</td>
</tr>
<tr>
<td>thin plastic</td>
<td>Soggy</td>
</tr>
<tr>
<td>Paper</td>
<td>Dry</td>
</tr>
</tbody>
</table>

David’s next steps:
Next time we do an investigation, try to plan to measure results rather than just looking at them.

Note: The use of a simple writing frame does not reduce David’s attainment.

David recognised with support the variables to change and measure and those to be kept the same. He made observations, which could have been measured using simple equipment, to compare the wrapping materials. He said what he had found out from the investigation but did not relate his findings to scientific knowledge and understanding.
Designing packaging for biscuits

Making things enquiry

Skills
C2; EP1, 2; ED5; ER1, 6.

Range
TSE3, 4.

Following a series of presentations of their findings from the previous enquiry, each pupil was asked to design packaging for biscuits. They were tasked with drawing the packaging, labelling it to show the material(s) it was made of and giving reasons as to why they had chosen this/these material(s).

Pupils worked with their thinking partners to discuss success criteria. David and Fay agreed that they were: stopping the biscuits from becoming soggy, looking good and using a material that could be recycled. They then worked individually on the design.

David’s next steps:
Talk to Fay and compare her design to yours. How is it different? How is it the same?
When questioned as to why he had used cardboard, David said that it was more important to recycle than to stop the biscuits becoming soggy. Also that biscuits were in boxes and these were made of cardboard. He found out from his investigation that plastic is the best material for biscuit packaging but prefers the recycling criterion. He linked his design (outcome) to success criteria and linked his learning to familiar situations, with support, such as his experience of biscuit packages and recycling.

The class carried out fieldwork to compare and contrast two local environments. They first studied the nature of the environment before looking at the organisms that were found in each one. Groups of pupils searched for organisms and tried to identify them, using simple keys.

David’s group was given two plastic hoops and card on which to write the names of the organisms they had found. David transferred his findings to a Venn diagram.

David followed a simple series of instructions safely to gather his findings, displayed his findings in a given format as a Venn diagram, identified simple patterns, showed what he had found out and used everyday experiences rather than scientific knowledge and understanding to try to explain his findings.

**Comparing two environments**

Pattern-seeking enquiry

**Skills**

C2; ED4, 5.

**Range**

IQ4, 6.
As a transition project, working on a cross-curricular design and technology theme, the pupils were asked to make shadow puppets of an animal that could be found in one of the environments. David planned his design after suggesting and looking at one website on the internet, with his partner, for ideas and information. He made a puppet of a rabbit with some support. Although the hand puppet looked like a rabbit, when it was used as a shadow puppet some of the definition was lost.

David was asked to evaluate his puppet.

David gave a simple explanation for shadow formation as a change in a physical phenomenon (i.e. how light travels), identified what worked and what didn’t and started to think about how his puppet could be improved.
Summary and overall judgement

Levels 2, 3 and 4 were considered and Level 3 was judged to be the best fit.

Overall much of David’s work is based upon everyday experiences although he is starting to develop his scientific knowledge and understanding.

Planning

David’s work shows that when planning an enquiry, he is able to suggest where to find evidence, information and ideas (a characteristic of Level 3). He said to his partner that they could look on the internet for ideas about how to make ‘Shadow puppets’, although he only used one website and so he didn’t find and use a variety of evidence, information and ideas (a feature of Level 4). In the same enquiry, and when investigating ‘Which is the best material for stopping biscuits becoming soggy?’, he planned, with support, the method to be used (a characteristic of Level 3). In the latter enquiry he used his everyday experiences to make a simple prediction (a feature of Level 3). Also in the process of designing ‘Shadow puppets’ and biscuit packaging, David used his knowledge and understanding to think about ‘What would happen if I used . . . ?’. Therefore David was predicting as he worked out his designs. David recognised with support the variables to change and measure and those to be kept the same, which is a characteristic of Level 4, in the fair test enquiry ‘Which is the best material for stopping biscuits becoming soggy?’. He agreed on some basic success criteria (a feature of Level 3) for ‘Designing packaging for biscuits’.

Developing

When developing an enquiry, David’s work on ‘Comparing two environments’ shows that he can follow a simple series of instructions safely to gather his findings (a characteristic of Level 3). In ‘Which is the best material for stopping biscuits becoming soggy?’ he made observations that could be measured using simple equipment (a feature of Level 3). In the ‘Litter survey’ enquiry he initially made enough observations to group the litter and made a simple record of his findings by constructing a tally chart (both characteristics of Level 2). However, he went on to display his findings in a given format as a bar chart and demonstrated that he is beginning to identify simple patterns (both features of Level 3) in both this enquiry and in ‘Comparing two environments’. David gave
an explanation based upon everyday experiences, for his findings (a characteristic of Level 3) in ‘Comparing two environments’. He gave a simple explanation for the differences between materials (a feature of Level 3) when he looked at litter that is attracted by a magnet and a simple explanation for changes in a physical phenomenon (a characteristic of Level 3) in the ‘Shadow puppets’ enquiry.

Reflecting

David consistently said what he had found out from his work (a feature of Level 3) in his enquiries. David’s work in ‘Designing packaging for biscuits’ shows that when reflecting on an enquiry he can link outcomes to success criteria (a characteristic of Level 3). He identified what worked and what didn’t and showed that he is beginning to think how his method could be improved (both features of Level 3) in the evaluation of his ‘Shadow puppet’. David links the learning, with support, to familiar situations (a characteristic of Level 3) when he designed his biscuit wrapping.
Mia is an 11-year-old learner in Key Stage 2.

Her teacher knows much more about Mia’s performance than can be included here. However, this profile has been selected to illustrate characteristic features of Mia’s work across a range of activities. Each example is accompanied by a brief commentary to provide a context and indicate particular qualities in the work.

Mia’s teacher judges that her performance in science is best described as Level 4.

As part of a theme on Space, pupils were asked to choose and research a planet in the solar system and present their findings to the class. The nature of the presentation was left to individual choice. Mia chose Saturn and used the internet and the school library to collect information.

Teacher: What sort of presentation are you going to do?

Mia: A ‘fact sheet’ for the class to read.

Teacher: How will you know if your leaflet is good?

Mia: I want it to be interesting for children to read so it needs some pictures.
On questioning, Mia had problems understanding some of what she had written. For example, she did not understand the term ‘core’ or ‘agriculture’. Mia found and used a variety of evidence, information and ideas, although this was limited to a leaflet and one website. She organised and communicated her findings using relevant scientific language. Mia decided upon some basic success criteria, referred to these when reflecting upon success and made a simple suggestion as to how she could have improved her work.
The rocket launch
Exploring enquiry
Skills
C2; EP2; ED5.
Range
HTW2, 3.

Pupils watched a video clip of a rocket launch. In pairs they discussed the variables that might affect the launch. Individually they wrote about their fictitious rocket launch.

The launch was successful. The rocket travelled 150m up and about 100m in distance. It was launched by an electrical current being sent to the small explosion allowing the rocket to defy gravity and travel 150m. When the rocket got off the ground, it swayed from side to side because the rocket had spoilers. The wind hit them, which made it move one way and the way the rocket was designed countered the wind. The speed got worse as the rocket went up because gravity got stronger and pulled it down.

Mia’s next steps:
Find out more about the forces involved in a rocket launch. You might like to look at the book ‘Forces’ in the science corner.

Mia used scientific knowledge and understanding to predict the outcome of her launch although her description contains confused scientific ideas. She used relevant scientific language in her description and explanation. She omitted to write about a number of variables, such as weather conditions or the materials the rocket could be made from. Had she discussed the materials, the evidence would also touch upon The sustainable Earth (TSE4) section of the Range.
Following a teacher-led lesson on forces, the class investigated their own rocket launch. They made rockets out of paper and put them on top of empty plastic bottles, which they squeezed for propulsion. Each group selected their own variable to change (independent variable). Mia’s group changed the size of the bottle.

**Making rockets**
Fair testing enquiry

**Skills**
C2, 3; EP4, 5, 7; ED1, 2, 3, 4, 5; ER2, 4.

**Range**
HTW2, 3.

Teacher: What are you going to measure?

Mia: How far the rocket travels longways.

Teacher: What are you going to change?

Mia: How big the bottles are

Teacher: So how is the size of the bottles different?

Mia: There’s one big one, a small one and one in the middle.

Teacher: Can you measure the size?

Mia: We can look at the number – it’s capacity I think.

Teacher: What are you going to keep the same?

Mia: The shape of the bottles.

Teacher: Will you try and keep anything else the same?

Mia: We need to squeeze the bottles with the same pressure and stay out of the way when they launch!

Mia recognised, with support, the variables to change and measure and those to be kept the same by answering the teacher’s questions.
Mia used standard equipment to measure and displayed her findings in a table she drew up herself and a simple line graph, with the axes and scales given by the teacher. She repeated the test for each bottle twice and could therefore be starting to consider reliability. However, the repeats might have been a group decision and further questioning is needed to clarify Mia’s understanding. She identified that one result didn’t fit the pattern and tried to explain it. In addition she suggested how to improve her method by repeating this test with a slightly differently shaped bottle. Mia used some scientific knowledge and understanding to explain her findings and draw conclusions.
Fact or opinion?
Classifying and identifying enquiry
Skills
C2; ED4, 6; ER5.
Range
TSE6.

Within the theme of Planet Earth, learners were asked to read a range of newspaper reports about environmental change and its effects. They were asked to choose one article and highlight ‘facts’ in one colour and opinions in another.

Brits red-faced on green issues

MORE than 80 per cent of Brits think that climate change is impacting on the UK - but 40 per cent of us are doing nothing to reduce our energy use, says research.

The Green Barometer - the first national survey of public opinion on green issues - is launched today by the Energy Saving Trust and will track what we think about the environment.

The poll shows that few people are actually making the necessary lifestyle changes, with 40 per cent doing nothing at all.

And while 32 per cent of Brits are prepared to choose a holiday destination that does not require flying in a bid to reduce carbon emissions, only four per cent have actually done so.

The report shows that when it comes to being green, strong measures are least popular.

The Green Barometer also shows a need for help - 60 per cent of Brits want the Government to let them know what they can do to save energy.

Chief Executive of the Energy Saving Trust Philip Sellwood said: “There’s lots of talk by politicians, industry and the media about environmental issues.”

“There are simple actions we can all do in the home to help reduce the amount of energy we use.”

If everyone in the UK...

Turned off lights when leaving an empty room, it would save 770,000 tonnes of CO₂ each year - enough electricity to power over half-a-million homes for a year.

Turned their TVs off, rather than leaving them on standby, it would save over 300,000 tonnes of CO₂ per year.

Waved for one short journey each week rather than taking the car, it would save around one million tonnes of CO₂ annually.

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April 02, 2007

Mia’s next steps:
Find out what ‘bias’ means using your dictionary. Read the article again and try to find any possible bias.
Mia has made decisions that show she is beginning to distinguish between ‘facts’ and opinions in the article. Some of her decisions needed to be questioned.

Teacher: How did you decide which are ‘facts’ and which are opinions?

Mia: It’s the words they use. ‘Facts’ have lots of numbers but opinions use words like ‘think’ and or ‘choose’.

Mia’s next steps: Look at another article and try to do the same thing. Do you still think your reasons are good ones? Write some success criteria for deciding between ‘facts’ and opinions.
Further within the Planet Earth theme, pupils studied St Lucia with a focus on geography and science. The teacher discussed how St Lucia had been formed from volcanic activity. The pupils were shown how to make a volcano using vinegar and bicarbonate of soda. In groups they discussed and carried out the enquiry. They produced individual write-ups.

**Mia’s next steps:**
Think about how you could have measured the vinegar and sodium bicarbonate and the distance that the lava travelled to make the enquiry more scientific.

*Note:* The use of a simple writing frame does not reduce Mia’s attainment.
Mia used scientific knowledge and skills to plan a fair test enquiry and predict outcomes. She identified key variables and distinguished between independent and dependent variables (without actually naming them) and those that she would keep the same. However she used the non-standard measure of a teaspoonful for the bicarbonate of soda, which limits possible attainment. She followed the planned method and organised and communicated her findings using relevant scientific language. Mia displayed her observations clearly in a table to describe her findings and identified the main pattern in her results. In the process she made links to what she thought would actually happen in a real volcanic eruption. Her conclusion describes the relationship between the two continuous variables of volume of vinegar and the speed of flow. It would have been better had Mia measured the distance the ‘lava’ travelled so that she could have drawn a line graph from which to work out the continuous relationship between the amount of vinegar and the distance travelled. Her reflection describes amending her method to give more spectacular results rather than improve it.

In the summer term, Mia’s class looked at a variety of musical instruments and the science behind how they work. Each group was asked to select an instrument to experiment with. Mia’s group chose a guitar. The group then discussed ‘How can a guitar make a sound?’ and individually wrote their answers.

Mia was asked how you could hear sounds from the guitar.

**How can a guitar make a sound?**

Exploring enquiry

**Skills**
C2; ED2, 4, 5, 7; ER5.

**Range**
HTW4.
After using traffic lights for learners to indicate their level of understanding, the teacher decided that further work was needed. She paired up green pupils with amber pupils (Mia was amber by self-assessment) and asked Mia’s pair to find out how a guitar can make sounds of different volume and pitch. They played the guitar again. After discussion Mia wrote:

"To make a louder sound you pluck the string harder. When you pluck the strings the thicker strings make a deep sound and the thin strings make a higher sound."

**Mia’s next steps:**
Talk to Ryan about what you have found out and then try to complete the sentence:
The thicker the string the …………… the sound.

Mia evidenced that she is starting to use some scientific knowledge to explain changes to sound; a physical phenomenon.

Mia was asked to describe how she had learned about sound and which way worked the best. She used a pre-drawn metacognitive caterpillar to show this.
Mia described how she learned and identified the way that worked the best.

**Teacher:** What do you mean by ‘knowing what to talk about better’?

**Mia:** I knew the questions to ask and I had thought about how to say them because I listened to Jo’s answers.

This dialogue evidenced that Mia is beginning to listen to others’ ideas and so has made informed decisions.

As part of the school’s transition arrangements, Mia’s class finished Year 6 on this topic. They continued to investigate sound within the context of energy changes at the start of Year 7. The ‘next steps’ statements and the ‘how I learned’ sections were very useful for teachers in the secondary schools who could use these to plan the first few weeks’ work.
Summary and overall judgement

Levels 3, 4 and 5 were considered and Level 4 was judged to be the best fit.

In general, Mia has a fairly good grasp of scientific language although she occasionally uses incorrect scientific terminology. For example at the start of Year 6 she was still confusing ‘melting’ with ‘dissolving’. However, given further teaching and enquiry work where she had to distinguish between the two processes this is no longer an issue. Her thinking is becoming more scientific and builds on her everyday experiences.

Planning

Mia’s profile shows that when planning an enquiry she can find and use a variety of evidence, information and ideas (a characteristic of Level 4) as evidenced in ‘Planet presentation’. The relevance of some of the information she used is questionable and therefore she did not find and use relevant evidence, information and ideas (a feature of Level 5). If Mia’s success criteria had been more wide-ranging and science specific she could well have been self-directed towards more relevant information. She uses scientific knowledge and skills to plan her enquiries and predict outcomes (a characteristic of Level 4) as shown in her write-up of ‘Does the mixture of lava affect the eruption of a volcano?’. This is a fair test enquiry and by identifying key variables and distinguishing between independent and dependent variables (without actually naming them) and those that she would keep the same she showed an aspect of Level 5. However, in ‘Making rockets’ she recognised, with support, the variables to change and measure and those to be kept the same (a feature of Level 4) when she was led by the teacher’s questioning. Mia uses scientific knowledge and skills to predict outcomes (a characteristic of Level 4) in ‘The rocket launch’ although her description has some confused scientific ideas. In ‘Planet presentation’ she decided upon some basic success criteria (a feature of Level 4) and although these are very simple, they were her own decisions.
Developing

When developing an enquiry, Mia’s work on ‘Does the mixture of lava affect the eruption of a volcano?’ is evidence that she can follow the planned method (a characteristic of Level 4). She makes qualitative observations (a feature of Level 4) in the same enquiry but would have improved her investigation by using standard equipment to measure within a given range using S.I. units (a characteristic of Level 4) as she did in the ‘Making rockets’ enquiry.

Across the profile she demonstrates that she can organise and communicate her findings using relevant scientific language (a feature of Level 4). Mia displays her findings in tables (a characteristic of Level 4) in both the ‘Does the mixture of lava affect the eruption of a volcano?’ and ‘Making rockets’ enquiries, with evidence that she can draw a simple line graph when the axes and scales are given (a feature of Level 4) in the latter. In the same two enquiries Mia also identifies patterns (a characteristic of Level 4) in her findings. From collaborative work, especially in the enquiry ‘How can a guitar make a sound?’, Mia shows that she is beginning to make informed decisions (a feature of Level 4). However, her teacher knows that Mia is being led by others in making decisions and further teaching is needed to increase Mia’s confidence in scientific knowledge so that she uses her own ideas in tandem with those of others. Mia is beginning to distinguish between ‘facts’ and opinions (a feature of Level 3) and is started on the path to recognise bias in the ‘Fact or opinion?’ enquiry. Mia uses some scientific knowledge and understanding to explain her findings (a characteristic of Level 4) in ‘Making rockets’. She uses some scientific knowledge and understanding to explain changes to physical phenomena (a feature of Level 4) in ‘How can a guitar make a sound?’, however this is not a strength of Mia’s work and needs to be built upon by further teaching of scientific knowledge. She is beginning to draw conclusions (a characteristic of Level 4) in some of these enquiries. Her conclusion in ‘Does the mixture of lava affect the eruption of a volcano?’ shows an aspect of Level 5 as she describes the relationship between the two continuous variables of amount of vinegar and the speed of flow, although hesitatingly. However, she would need to have measured the distance travelled rather than just observing the speed of flow in order to draw a line graph from which to work out the relationship to evidence this level description.
Reflecting

When reflecting on an enquiry, as in ‘Planet presentation’, Mia’s profile shows she is linking outcomes to success criteria (a characteristic of Level 3). In the same enquiry and in ‘Making rockets’ she says how to improve the method (a feature of Level 4) and although she attempts this in ‘Does the mixture of lava affect the eruption of a volcano?’ her suggested amendments would just give more spectacular results rather than improving the method. Mia demonstrates that she can describe how she has learned and identify the way that worked the best (a characteristic of Level 4) when reflecting on her learning in ‘How can a guitar make a sound?’. She links the learning of her findings of the model volcano to similar situations (a feature of Level 4), i.e. what would happen in a real-life volcanic eruption in the enquiry ‘Does the mixture of lava affect the eruption of a volcano?’.
Tom is an 11-year-old learner in Key Stage 2.

His teacher knows much more about Tom’s performance than can be included here. However, this profile has been selected to illustrate characteristic features of Tom’s work across a range of activities. Each example is accompanied by a brief commentary to provide a context and indicate particular qualities in the work.

Tom’s teacher judges that his performance in science is best described as Level 5.

The class has been working within the topic ‘Space Missions’, linking ideas for space flight with survival.

Pupils were asked to produce a map of the solar system. They independently thought about and made a record of what they already knew, what they needed to find out and where to find it. Tom drew a concept map.
Once he had found relevant information, considered the different interpretations of the solar system and made decisions as to his own map, he drew the map below. Tom also wrote a list of the references he had used.

Tom’s next steps:
Do you think any of your sources may be biased? Why do you think this? Add some notes to your references to show your ideas.

Tom found and used relevant information, he organised and communicated his information integrating different forms into his map and produced a simple map of the solar system.
The class were given a ‘source square’ to interrogate in groups, each with different images of the solar system. Tom chaired his group and organised their tasks.

The group observed the image carefully and used scientific knowledge and understanding to infer. However, the discussion became quite heated when they were deciding what else they needed to know. The teacher listened to the group’s deliberations. Tom asked if the group thought the scale of the photo was correct. The group was worried that the solar plume was about to burn Earth!

**Tom:**
Can I look at the NASA website to find out more? I think I should check this with other websites too.

**Teacher:**
Why do you want to check?

**Tom:**
It’s because the photo is from NASA but I don’t think it’s right – if the Sun was that close it would be so hot that there would be no life on Earth.
Tom wanted to check the reliability of the information. He discovered that the image was not factual but a composite image used for discussion of ‘What would happen if . . . ?’. In Tom’s opinion NASA is the most famous and knowledgeable source of information about space, although he now recognises that it’s not just the source of information that is important but thinking about whether it could be ‘factual’ or not. Tom wrote his own next steps.

**Tom’s next steps:** (written himself)
Check information and don’t always believe it just because it comes from somewhere you think is right.

When Tom reported back to the class as to his group’s findings, he used detailed and at times abstract scientific knowledge and understanding. He gave reasons for questioning the image’s authenticity, methods he used to check reliability and made links with other learning including Sun spots and solar plumes.

For ‘Mission Possible?’ the class were given the brief to plan a space journey to Mars using a computer model. They made decisions and manipulated variables to try and reduce the mission cost whilst ensuring its success – their success criteria.

**Mission Possible?**
Using and applying models enquiry
**Skills**
C2; ED4, 5, 7;
ER2, 3.
**Range**
IO2, TSE2, HTW3.
In the group’s discussion, overheard by the teacher, Tom used scientific knowledge and understanding of forces when he considered the thrust required for take-off and he compared this to the cost for each fuel. He also recognised that the rocket needed to use up all the fuel before landing, for safety. He considered others’ views to make his decisions. As the variables were manipulated, Tom regularly checked progress. Once the model was complete, each pupil reflected on their success and described the reasoning for decisions. Tom explained independently why his group changed the pay-load of the rocket; the choice of fuel and the choice of personnel.
Mission Possible??

My group’s trip to Mars was successful because our price was very low compared with the other groups and we managed to get there and back. The price was very low because we took out the Moon Buggy and the telescope, because they were the heaviest pieces of equipment and we decided we didn’t need them. So less force would be needed for take-off and so less fuel. We also took some of the lightest equipment like lasers and a three year supply of chocolate because then it wouldn’t take so much fuel to get the rocket off the ground. We needed the lasers in case there was enemy life on Mars and we needed the chocolate as a source of carbohydrates as well as the food supplies.

We used fuel called Superfast because it had the highest amount of thrust. Although Superfast was the highest priced product it would produce more thrust than the other fuels and so we would get there quicker. Also we had reduced the mass of the rocket so it would use less fuel. If we had used Willthisdo fuel, it is the lowest priced fuel, but it has the lowest amount of thrust so we would end up taking so much fuel that the price would have been much more. Also we might not have had room for anything else.

We weighed ourselves without our shoes on because if we are lighter it won’t take as much thrust to put the rocket in the air. We were going not to take the nutritionist but we decided to take her with us after all because we thought it was important to take someone who could tell us how to eat a healthy and varied diet. We took the mission scientist so she can explore Mars and check for signs of life. We took the crewman because who else was going to do the cleaning? We took an astronomer because he could study the stars and tell us where we are. We took a navigator to tell us what was coming ahead.

Tom’s next steps:
Find out how an astronomer and a navigator might work together. You may like to try the book 'Deepest Space' in the library.
The problem of survival as astronauts in an uninhabitable place was the focus of this activity. Each group was given items typed on card to prioritise. Tom’s group prioritised using diamond ranking and then answered questions from the class as to their decisions.

**Moon Crash Landing 2020**

Exploring enquiry

**Skills**
C2; EP2, 7; ED5, 7; ERS, 6.

**Range**
IO2, TSE2, HTW2, 3.

**Tom’s next steps:**
Think about what else you might need for survival on the Moon, especially remembering gravity.
Tom used scientific knowledge and understanding to justify his group’s decisions (findings). In order to make each of these decisions, Tom would have had to think ‘What would happen if . . . ?’ therefore his decisions are based on predictions. He linked his learning to familiar but dissimilar situations by suggesting that using the dinghy as a transport mechanism would reduce the energy expended and therefore require less food.
The class was asked to review and evaluate the thinking/learning strategies they had used in this activity.

Tom clearly identified the thinking/learning strategies he has used.

Having been taught circuit symbols and reminded of the functions of circuit components, the class had been given opportunities to investigate circuits within the theme of Electricity. They were then asked to design and build a lighthouse, selecting their own equipment and bringing other materials from home.

Tom planned his enquiry by thinking about what was needed for success. He listed the following:

- working light
- turn light on and off
- high from ground.

**How can you make a model of a lighthouse?**

Using and applying models enquiry

**Skills**
C2; EP1, 2; ED1, 5; ER1, 3, 4, 6.

**Range**
HTW1, 5.
He justified these to his teacher by referring to his knowledge of a real lighthouse. For example, ‘The lighthouse needs to be high from the ground so that the light can travel further with nothing in its way. This means that more ships will be able to see the light from further away.’

He then built several versions of circuits with differently constructed switches until he was happy that the circuit would work once placed in his structure.

Tom used scientific knowledge and understanding to build his lighthouse including a simple model of current flow, which he has also used to explain his findings, i.e. changes to a physical phenomenon. He regularly checked progress and revised his method whilst building his lighthouse. His reflections show how he would improve his design to make it more like a real lighthouse.
The teacher asked him about his success criteria.

**Teacher:** Did you meet all your success criteria?

**Tom:** Yes – because it’s a model it can’t be that high. But I don’t think my success criteria were good enough.

**Teacher:** Why weren’t they?

**Tom:** They were too simple and I thought more about a model than the real thing.

**Teacher:** Can you suggest how you might change them?

**Tom:** I should have thought more about the materials it was made from. They should have been waterproof and strong.

**Tom’s next steps:** Try to write a new set of criteria for success next to the original one.

In this conversation, Tom is beginning to evaluate how far his success criteria fully reflect successful outcomes.
The teacher gave the class a series of questions to guide them through the investigation. This does not reduce attainment but gives a structure for the learners’ ideas. Tom systematically planned, carried out and recorded the results of the investigation using a light sensor. He distinguished between independent and dependent variables and recognised those that needed to be kept the same.

How can the brightness of a bulb in a circuit be changed?
Using and applying models enquiry

Skills
C2; EP1, 2; ED1, 5; ER1, 3, 4, 6.

Range
HTW1, 5.

**How would you do it?**
I could put more batteries in the circuit and see if this would change the brightness.

**What do you think would happen?**
The more batteries I use the brighter the bulb will be.

**Why do you think this?**
It should do because the more batteries the bigger the current will be.

**What are your variables (things that might affect your results)?**
If I change the number of batteries – that’s the independent variable. The brightness is the dependent variable. I could measure using a light metre. It measures brightness in lux. The experiment needs to be done in a dark room to make sure my test is fair and there is no other light to make the measurements unfair. I would have to keep the equipment the same too.

**Results**
When I added one battery to the circuit, the bulb was very dim, with only 4 lux. As another battery was added, the bulb became much brighter reading 22 lux. The third battery increased the brightness to 29 lux and 4 batteries was 30 lux. When I tried a 5th battery the brightness was the same because it was 30+ and off the scale of our light meter.

<table>
<thead>
<tr>
<th>Number of batteries (independent variable)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brightness in lux (dependent variable)</td>
<td>4</td>
<td>22</td>
<td>29</td>
<td>30</td>
<td>30+</td>
</tr>
</tbody>
</table>

**What did you find out?**
I noticed that the more batteries, the brighter the bulb. This is because there is more current. This makes the bulb brighter. If I extrapolated the graph, I think 5 batteries might be 40 lux because it will keep getting brighter. But I think even more batteries would blow the bulb because the current would be too much. Also I would need a different light meter because this one only said 30+ lux.

I think that you see this in a dimmer switch in your house. You can alter the brightness by turning the dimmer up or down. You are increasing the current to make it brighter.

**Success Criteria**

<table>
<thead>
<tr>
<th>Did you describe what happened?</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you repeat your measurements?</td>
<td>No</td>
</tr>
<tr>
<td>Did you refer to your results?</td>
<td>Yes</td>
</tr>
<tr>
<td>Did you draw a graph of results?</td>
<td>Yes, bar chart</td>
</tr>
<tr>
<td>Did you explain the graph?</td>
<td>Yes</td>
</tr>
<tr>
<td>Could you apply this idea to everyday life?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

If I was to repeat this experiment I would make sure I repeated my readings of the light metre to check for reliability. I would also get a better light metre that would show a longer scale and go up above 30 lux. I would also like to keep adding the batteries to see how many it took before the bulb blew.

**Tom’s next steps:**
Try to find out more about current flow. Use the BBC website to help you.
The teacher questioned Tom as to his selection of a bar chart to show his findings.

Teacher:
Why did you choose to draw a bar chart?

Tom:
Because each battery is a whole, separate thing.

Teacher:
What do you mean?

Tom:
You can’t have half a battery, you have a full one, or two or three or nothing.

Tom used scientific knowledge and understanding to explain his findings, which are changes to a physical phenomenon using a simple model of current flow. His conclusion was consistent with his findings and describes the relationship between the two variables shown by his bar chart. He linked his learning to dimmer switches at home and therefore with a dissimilar but familiar situation. The teacher gave the class success criteria so that they could self-assess. This led Tom to suggest improvements in reliability and the selection of the light meter.
Summary and overall judgement

Levels 5 and 6 were considered and Level 5 was judged to be the best fit.

Tom has a systematic approach to his science enquiries. He has a sound grasp of scientific knowledge and uses this to explain his findings to good effect. He confidently uses scientific language. He enjoys working independently but recognises the importance of sharing ideas to build his understanding.

Planning

Tom’s profile shows that when planning an enquiry he can find and use relevant evidence, information and ideas (a characteristic of Level 5) as in ‘Map of the solar system’. When carrying out the fair test enquiry, ‘How can the brightness of a bulb in a circuit be changed?’, Tom’s profile shows that he can systematically plan an enquiry and identify key variables and distinguish between independent and dependent variables and those that he will keep the same (both features of Level 5). When prioritising the equipment in ‘Moon crash landing 2020’ he makes predictions based on scientific knowledge and understanding (a characteristic of Level 5). In ‘How can you make a model of a lighthouse?’ Tom gives some justification for his success criteria (a feature of Level 5).

Developing

When developing an enquiry, Tom’s profile shows that he regularly checks progress and revises the method where necessary (a characteristic of Level 5). This is evident in ‘How can you make a model of a lighthouse?’ and in ‘Mission possible’. He organises and communicates his findings integrating different forms in various presentations (a feature of Level 5) as shown in ‘Map of the solar system’ and records these systematically (a characteristic of Level 5) in the fair test enquiry ‘How can the brightness of a bulb in a circuit be changed?’. In the latter enquiry he selects the most appropriate type of graph or chart to display data recognising the discontinuous nature of the variable and shows that he is starting to consider reliability (both features of Level 5). However, in the ‘Questioning an image of the solar system’ enquiry, Tom explores the image by considering reliability and offering some explanations for any anomalies (a characteristic of Level 6). In the same enquiry he...
is starting to use abstract scientific knowledge and understanding when explaining his findings (a feature of Level 6). However, in the main throughout his profile Tom uses scientific knowledge and understanding, including simple models, when explaining his findings (a characteristic of Level 5) as shown in the ‘How can you make a model of a lighthouse?’ enquiry. Also he uses scientific knowledge and understanding, including simple models, when explaining changes to physical phenomena (a feature of Level 5) in ‘How can the brightness of a bulb in a circuit be changed?’ investigation. Throughout his profile Tom draws conclusions that are consistent with his findings and considers others’ views to inform opinions and make decisions (both characteristics of Level 5).

Reflecting

Tom’s profile shows that when reflecting on an enquiry he is beginning to evaluate how far success criteria fully reflect successful outcomes (a feature of Level 5) in ‘How can you make a model of a lighthouse?’ He identifies the learning/thinking strategies he has used (a characteristic of Level 6) in ‘Moon crash landing 2020’. In several enquiries Tom links the learning to dissimilar but familiar situations (a feature of Level 5).
Sian is a 14-year-old learner in Key Stage 3.

Her teacher knows much more about Sian’s performance than can be included here. However, this profile has been selected to illustrate characteristic features of Sian’s work across a range of activities. Each example is accompanied by a brief commentary to provide a context and indicate particular qualities in the work.

Sian’s teacher judges that her performance in science is best described as Level 5.

At the start of the topic ‘Connections’, the teacher used the first few lessons to ascertain prior knowledge in the area of classification. She set pupils the task of finding out the names, features and examples of the vertebrate groups. The research was carried out in pairs with the pupils independently presenting their findings.

**Vertebrate groups**
Classifying and identifying enquiry

**Skills**
C1, 2; EP3; ED3.

**Range**
underpinning IO4.

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**Sian’s next steps:**
Next time you find information give the references and start to think about whether you trust the source of information.
Further into this topic the learners were asked to research the features of an environment and then design an imaginary animal that could live there.

The teacher asked Sian how she had decided on her ideas about the conditions in the pond.

Sian: I looked up the word ‘stagnant’ and it said this meant the pond had no current. I didn’t understand this so I looked in a couple of science books in the library. They said it was a pond with very little oxygen.

Sian’s next steps: How do you think your animal would breath? Look at the table of vertebrate groups. Try to add something about this to your diagram.

Sian found and used relevant information, organised and communicated her findings integrating different forms into the presentation and used scientific knowledge when explaining the differences between organisms.
Sian again found and used relevant information about the conditions in the pond, this time from books. She has used scientific knowledge and understanding to predict, describe and explain the features of her animal, which are all related to the conditions in the pond. As her target shows she had not taken the limited oxygen in the pond into account in her design.

The pupils were then shown a video clip of life in an economically developing country where water is scarce. They were asked to think about how a sample of pond water could be changed to water that is fit to drink. In pairs they decided on their success criteria and recorded as many ways as they could to clean the water.

Once the pond water was boiling they realised that the water was being evaporated off and they would have been left with debris rather than water. Sian suggested they try to collect the steam. Recognising the safety issues the girls spoke to their teacher and decided not to do this but to add it as an improvement in their write-up.
Sian made predictions based on simple scientific knowledge and by regularly checking progress she tried to revise the method when she recognised that it wasn’t working. She amended her original success criteria and therefore demonstrated that she is beginning to evaluate how far her success criteria fully reflect successful outcomes. By working well collaboratively she considered others’ views to inform her decisions.

The teacher asked Sian to reflect on her learning and thinking by using a reflection triangle.

Sian’s next steps:
Did you use any strategies or tools to help you — in remembering and planning? Look in your thinking log for the names.

Sian used learning and thinking terms to describe what she had done. She identified ‘brainstorming’ as a strategy she had used in order to learn. Her other ideas sum up how she worked without getting to the ‘How I did this’. Sian linked her learning to dissimilar but familiar situations by mentioning the possible use of her strategy and the ways she worked in other subject areas and in her life outside school.
The pairs were asked to think about how their method of cleaning pond water could be amended and scaled-up to use in the economically developing country. Individually they produced a poster suitable for the class.

Sian used scientific knowledge and understanding to explain her ideas and changes to materials and has linked the learning to a dissimilar but familiar (from the video clip) situation.

How could people in an economically developing country get clean water?

Making things enquiry

Skills
C2; ED4; ER4.

Range
IO7; TSE1, 2.

Sian’s next steps:
Look in your text book to find out the difference between steam and water vapour. Make any changes to your diagram to take this into account.

Sian used scientific knowledge and understanding to explain her ideas and changes to materials and has linked the learning to a dissimilar but familiar (from the video clip) situation.
What makes a good investigation?
Exploring enquiry

Skills
C2; EP1; ED7.

Range
TSE1.

Before carrying out an investigation on changes of state, the class was given two samples of fictitious pupils’ investigations. They were asked to discuss in groups what features make one piece of work better than the other and individually to write a ‘checklist for success’ for their own investigation plan and write-up.

1. I am going to place 10 drops of the liquid onto the glass using a pipette
2. I will measure out 100 cm$^3$ of water and place it in a beaker
3. I will find the temperature of the water using a thermometer
4. I will put the glass on top of the beaker as shown in my diagram
5. I will time how long it takes for all the liquid to evaporate
6. I will do the experiment using 5 different temperatures of water
7. I will repeat the whole experiment and place my results into my results table

Variables:
What I change
The temperature of the water that is heating the liquid

What I measure
The time it takes for all the liquid to evaporate

Fair testing
1. Same amount of liquid (10 drops)
2. Same amount of water (100 cm$^3$)
3. Same distance between the water and the glass
4. Same size of glass in area and thickness

Comment on variables
It is going to be difficult to have exactly the same amount of liquid by counting the number of drops. It may be difficult to decide when all the liquid has evaporated as it is a clear liquid. We will have to use the same beaker and glass each time otherwise the distance between the hot water and the liquid could change.

Comment on reliability
I can only check that my results are reliable if I repeat the experiment. If they are reliable then the times should be close together at each temperature. If they are far apart I would have to do that test again to decide which is the reliable time to use for my results.
Sian identified the main features and so decided on her success criteria giving some justifications. Again Sian considered others’ views to make decisions, this time on her success criteria.

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**Task 1**

*Name: SIANLIECQ*

**Science: Guidance for Key Stages 2 and 3**

How does the temperature affect the evaporation of a liquid?

**Prediction:**
I think that when a liquid is hot it will evaporate quickly.

**Why does this happen?**
This happens because when a liquid is hot it is easier for it to change into a gas. It is like what happens to a puddle of rain in the summer when it quickly goes because it is hot but it takes longer for it to go when it is cold in the winter.

**Plan:** (you may decide to draw a diagram to help you plan this investigation)

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I am going to put some of the liquid onto the glass and then put it on top of a beaker full of water. I will time how long it takes for the liquid to disappear. I will do this again but I will use hotter water in the beaker every time that I do it. I will draw a results table for my results that I get for my experiment.

**Variables:**
- What I change
- How hot the water is that I use
- What I measure
- The time it takes for all the liquid to go

**Fair testing**
- Use the same glass to put the liquid on
- Try to start and stop the clock at the right time
- Don’t use more liquid for one experiment than another

**Comment on variables**
I think that it will be difficult to see this liquid and to stop the clock at the right time.

**Comment on reliability**
I will have to do the experiment the same way each time or it will not be fair. If I do repeat it the same way my results will be more accurate.
How does the surface area affect the rate of evaporation?

Fair testing enquiry that requires the use of a model

Skills
C2, 3; EP2, 4, 5, 6; ED1, 2, 3, 4; ER1.

Range
TSE1, 2.

Sian then planned and carried out her investigation.

How does the surface area affect the rate of evaporation?

What is your prediction?
I think the bigger the surface area the faster the water will evaporate because more water is in contact with the heat. The heat will make the water change from a liquid to a gas. Because it will move faster and spread out more, so more surface equal more heat, touching the water equals faster evaporation.

Plan
What is your independent variable? The surface area of the container.
What is the dependent variable that you will measure? Time it takes to evaporate the water.
What other variables need to be controlled? ..............................................................
I will keep the amount of water and the height the same. The amount of water is 200ml.

Method
1. Set up five containers with different surface area.
2. Put the same amount of water in each one.
3. Use a hairdryer to speed up the evaporation.
4. Time how long it takes the water to evaporate from each container.
5. Find out the surface area of each container by finding each container upside down on graph paper and counting how many square
6. Write a table to show the results.
7. Draw a graph of the surface area against the time it takes to evaporate.
Sian's next steps:
Read your conclusions again. Try to rewrite them using the ideas of 'particles'. Look in your text book to help you.
Sian made a prediction based on a simple model of change of state. Her model is not an abstract one as she didn’t use ideas of particles. She systematically planned and carried out a fair test although her method could have been more specific by stating how the hairdryer was to be used. Within this she identified key variables, distinguished between independent and dependent variables, selected measuring equipment to make a series of measurements and recorded her findings systematically using S.I. units. Sian used her line graph to describe the relationship between the continuous variables of surface area and the time taken to evaporate. Therefore she drew a conclusion that is consistent with her findings.

The learners were asked to review their success criteria against their write-ups in pairs so that they could set their own next steps.

Sian demonstrated that she was beginning to evaluate how far her success criteria fully reflect successful outcomes and is starting to consider reliability.

Sian’s next steps: (written herself)
Repeat the experiment to check my results.
The teacher gave the class the task ‘Energy resources’ to assess their learning of a topic they had just completed. The assessment focused on the learners’ use of scientific knowledge and their understanding of bias and the reliability of information. These aims were shared with the class at the start. The class worked in pairs to gather evidence and present their findings as a report for the school governors.

Energy resources
Making things enquiry
Skills
C1, 2; EP3; ED4, 6, 7.
Range
IO6, HTW6.

Energy resources
Recently the school was successful in gaining the ‘Eco Schools’ award. However, the school’s Governors have a concern over the choice of energy resources used by the school. At present the energy used by the school is obtained from the burning of fossil fuels. It has been suggested that as a school we should be using a more sustainable energy resource, e.g. burning ‘fast growing’ trees.

The Governors would like learners to research the potential advantages and disadvantages of changing the energy resource used from fossil fuels to ‘fast growing’ trees.

Your task is to produce a report for the Governors.

Sian’s next steps:
Talk to Joshua’s group about their poster. Ask them about the importance of using ‘fast growing’ trees rather than normal trees. Add these ideas to your poster.
Sian and her partner found and used relevant information from a text book and from their own work. They organised and communicated their findings integrating these different forms into the report and used scientific knowledge and understanding to explain them. However, the report only discusses biomass rather than recognising the full implications of using ‘fast growing’ trees. Once they had finished, the teacher asked the pupils to evaluate their sources of information using a writing frame.

Sian’s next steps:
Look up in a dictionary what the word ‘reliable’ means. When else do we need to think about reliability in science lessons?

Sian’s responses indicate that she identified possible bias and has started to consider reliability of information.
Summary and overall judgement

Levels 4 and 5 were considered and Level 5 was judged to be the best fit.

Sian is using scientific knowledge and understanding throughout her work. However, she struggles with more abstract scientific ideas and lacks confidence when applying her scientific ideas to new situations.

Planning

Sian’s profile shows that when planning an enquiry she can find and use relevant evidence, information and ideas (a characteristic of Level 5). This is evident in several of her enquiries, such as ‘Vertebrate groups’. However, in each case the number of information sources she used was minimal. In ‘How does the surface area affect the rate of evaporation?’ she shows that she can systematically plan an enquiry, and make predictions based on scientific knowledge and understanding, including a simple model of changes of state (both features of Level 5). Also in the process of inventing her ‘Imaginary animal’ and her design to clean pond water in an economically developing country, Sian used scientific knowledge and understanding to think about ‘What would happen if . . . ?’. Therefore Sian was using predictive thinking to work out her designs. In the fair test enquiry ‘How does the surface area affect the rate of evaporation?’, she identifies key variables and distinguishes between independent and dependent variables and those that she will keep the same (a characteristic of Level 5). Sian decided upon some basic success criteria (a feature of Level 4) in ‘How can we clean pond water?’. She took this further as she gave some justification for her success criteria (a characteristic of Level 5) in ‘What makes a good investigation?’.

Developing

When developing an enquiry, Sian selects measuring instruments that allow her to make a series of measurements (a feature of Level 5) in the enquiry ‘How does the surface area affect the rate of evaporation?’. She regularly checks progress and revises the method (a feature of Level 5) as evidenced in ‘How can we clean pond water?’. Throughout her profile she organises and communicates her findings integrating different forms in various presentations (a characteristic of Level 5) and this is especially evident in ‘Vertebrate groups’.
In ‘How does the surface area affect the rate of evaporation?’ she records her findings systematically, using S.I units and uses a line graph to describe the relationship between two continuous variables (both features of Level 5). In the same enquiry and in ‘Energy resources’ Sian shows that she is starting to consider reliability and she also identifies bias in the latter (characteristics of Level 5). Throughout her profile Sian uses scientific knowledge and understanding, including simple models, when explaining her findings (a feature of Level 5). In ‘Vertebrate groups’ she uses scientific knowledge and understanding when explaining differences between organisms whilst in ‘How could people in an economically developing country get clean water?’ she uses a simple model when explaining changes to materials (both characteristics of Level 5). Sian draws conclusions that are consistent with her findings (a feature of Level 5) throughout her profile and also works collaboratively and considers others’ views to inform opinions and decisions (a characteristic of Level 5).

Reflecting

Sian’s profile shows that when reflecting on an enquiry she is beginning to evaluate how far success criteria fully reflect successful outcomes (a feature of Level 5) in ‘How can we clean pond water?’ and ‘How does the surface area affect the rate of evaporation?’. She identifies the learning/thinking strategy she has used (a feature of Level 5) in her reflection triangle in ‘How can we clean pond water?’. In the latter enquiry and in ‘How could people in an economically developing country get clean water?’ she links the learning to dissimilar but familiar situations (a characteristic of Level 5).
Amy is a 14-year-old learner in Key Stage 3.

Her teacher knows much more about Amy's performance than can be included here. However, this profile has been selected to illustrate characteristic features of Amy's work across a range of activities. Each example is accompanied by a brief commentary to provide a context and indicate particular qualities in the work.

Amy's teacher judges that her performance in science is best described as Level 6.

The class worked on a cross-curricular theme of ‘Drugs in Society’ with PSE. Initially the teacher asked paired pupils to draw a concept map of everything they already know about drugs. She used these to plan the next few weeks’ work.

Each pair was asked to choose a drug, from the list of insulin, steroids, paracetamol and caffeine, to find out about and present to the class. Amy and Chloe chose insulin.

The teacher listened to the pair’s planning.

**Amy:**
We could look on the internet; on the NHS website or on one of the doctors’ help sites. We could go to the doctor's and ask if they have any leaflets, talk to someone who's diabetic and look in medical books.

**Chloe:**
What shall we have as our success criteria?
Amy suggested a variety of methods to gather information for her enquiry and justified her success criteria for a successful presentation.

They researched and presented their findings as a PowerPoint presentation.

Amy: It needs to be clear and simple and easy to read or listen to – so we’ll use bullet points – just giving the important scientific information. It needs to be interesting otherwise people won’t listen or read it – so we’ll also put some pictures in. The language needs to be easy enough for everyone in the class to understand. We might need to do that with the science too! Could we put sound in – maybe a real interview or something? We could ask Mark – he’s diabetic, about how it affects his life. The best way would be to do a PowerPoint so all these could be in it and it would be easy to tell the class about it all.
**What does insulin do?**
- Takes glucose out of the blood and puts it in cells.

**Why does insulin do this?**
- After you eat there is a lot of glucose in the blood.
- It needs to get into cells for respiration:
  \[ \text{Glucose} + \text{oxygen} \rightarrow \text{carbon} + \text{water} \]
- Energy is released.
- So we have energy for doing things – moving, breathing.

**What is diabetes?**
- There are 2 types:
  - Type 1 is when you are young.
  - Type 2 you get when you are older.
- Diabetics do not make enough insulin or can’t use it properly.
- Glucose stays in the blood.
- You can die from diabetes if you don’t have any insulin.

**How is insulin made?**
- It used to be made from squashed pigs pancreases.
- Some people died when taking pig insulin. Their bodies had an immune response against it with antibodies attacking the insulin because it wasn’t human insulin.
- So...
- Now human insulin is made from bacteria – using genetic engineering.

**Other uses of insulin**
- Body builders use it as the glucose goes into muscle cells and is converted into glycogen – the main carbohydrate in muscles. This increases their muscle bulk.
- Dentists sometimes use it in very small doses as it speeds up healing of tissues in the mouth and can help pain.
- Research is trying to find out other uses such as helping migraines and other diseases.
They organised and communicated their findings in a way that was fit for purpose and audience. Amy presented to the class. She explained the function of insulin and its effect on the human body; what diabetes is; how insulin is manufactured and how it works when used illegally as a body-building drug. The presentation also had a brief interview with Mark, a Year 10 learner, who is diabetic, explaining how the disease affects his life. She explained their findings using abstract ideas, recognised that a number of factors and/or processes may have to be considered when explaining changes and showed some evidence of starting to link these. The pair had used a wide range of perspectives to inform their decisions and also linked the science learning to body-building, an unfamiliar situation.

The teacher asked the class to suggest two questions for Amy and Chloe, to help them improve their work.

Amy’s next steps:
(from the class)
Did you meet your success criteria? Are there any other success criteria you could have used?

Amy:
I think we did meet our success criteria. But what’s important is whether you all think we did. We wanted it to be clear, simple, informative, interesting and enjoyable.

Teacher:
Are there any other success criteria you could have used?

Amy:
(thinks for a minute) I suppose the main one we missed was that the science in it had to be spot on.

Teacher:
What do you mean by that?

Amy:
The science should be ‘right’, not biased and we need to think about how reliable the information was.

Teacher:
How could you check this?

Amy:
We did use trustworthy sources but maybe we could have checked the information more with other ones we trusted too.
Amy demonstrated she is beginning to evaluate how far her success criteria fully reflect successful outcomes and considers the reliability of the information as she justifies why amendments need to be made to her methodology.

A presentation on caffeine from another pair of learners caused much discussion in class especially as there had been recent newspaper articles about how caffeine affects the body. The teacher decided to try and help learners answer some of the questions that arose by carrying out an investigation on caffeine.

For homework the class was asked to find out which foods and drinks contain caffeine and how much caffeine per 100g each one contains. In class they used this information to plan and carry out an enquiry in pairs to find out how caffeine affects heart rate. They produced their own write-ups. The teacher had permission from parents/guardians to carry out this experiment.

### How does caffeine affect the heart rate?

**Fair test enquiry**

**Skills**
C2, 3; EP2, 4, 5, 6; ED1, 2, 3, 4, 5, 6; ER2, 4.

**Range**
IO3.

How does caffeine affect the heart rate?

**What I know**
Caffeine is a stimulant drug. It makes people feel more alert and able to concentrate. It speeds up the heart rate and increases blood pressure. Some athletes use it to give them an energy burst just before they start a race this might make them have a faster start. Caffeine is found in lots of drinks such as cola, coffee and tea. It works because it has an effect on the heart itself and an effect on the part of the brain that controls heart rate. It speeds up the messages between nerve cells. If the heart beats faster the muscles will have more oxygen and glucose for respiration and so will release more energy.

Glucose + oxygen $\rightarrow$ carbon dioxide + water $\rightarrow$ with released energy

**What I am going to do**
Compare the heart rate of two people. One will drink a caffeinated fizzy pop and the other will drink a decaffeinated pop. The caffeinated drink contains 45.6mg of caffeine and the decaffeinated drink contains no caffeine.

**Prediction**
From what I know I think that the pulse rate of the person who has drunk the caffeine pop will go up in about 2 minutes – as athletes take the caffeine just before a race, it will stay high through the 15 minutes. I think this because the caffeine is in a liquid so it will pass down the digestive system quickly and be absorbed quickly maybe in the stomach like aspirin. As athletes use caffeine to give them an energy burst to get through a race and races can take longer than 15 minutes.

**Variables**
- Independent variable — mass of caffeine in the drink—45.6mg or none.
- Dependent variable to measure — heart rate by taking the pulse rate per minute. We will carry on taking the pulse rate for 15 minutes after the drink.

**Control variables**
- type and quantity of pop — the same type, 330ml can, one with caffeine and the other without.
- caffeine already in the body. It’s important that the two people don’t have any caffeine in any food or drink before you start the experiment. So no caffeine before 9am that day.
- temperature of body and room. The temperature of the room will stay the same and so should the body temperature.
- movement. We must both stay as still as we can because movement might speed up the heart rate. Also we must not run around before the lesson.
- level of excitement. We will both try and stay calm throughout the experiment so our heart rates stay the same except for the caffeine.
Plan
1. Rest for 10 minutes then get your partner to take your pulse rate. This is called the resting pulse.
2. Take the resting pulse again and again until you get three readings the same. This makes sure that your resting pulse is reliable.
3. Drink the can of pop, one person with caffeine and one without, in 3 minutes.
4. Take your pulse again every minute for the next 15 minutes.
5. Record your results in the table.
6. We are going to take our pulse over 30 seconds and then multiply it by 2 to get rate in a minute – as we did in the exercise investigation.

Amendments
We noticed that my pulse rate was still very high after 15 minutes so decided to carry on taking it until it started to drop.

Results

Resting pulse

<table>
<thead>
<tr>
<th></th>
<th>Eleri</th>
<th>Amy</th>
</tr>
</thead>
<tbody>
<tr>
<td>72</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>76</td>
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<td>74</td>
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</tr>
</tbody>
</table>

So the resting pulse is 74 for Eleri and 76 beats per minute for Amy.

Experiment

<table>
<thead>
<tr>
<th>Time, in minutes</th>
<th>Pulse rate per minute</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without caffeine - Eleri</td>
</tr>
<tr>
<td>1</td>
<td>76</td>
</tr>
<tr>
<td>2</td>
<td>74</td>
</tr>
<tr>
<td>3</td>
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<tr>
<td>18</td>
<td>74</td>
</tr>
</tbody>
</table>
Graph showing pulse rate per minute against time in minutes (with caffeine and without caffeine)
Amy made predictions using abstract scientific ideas and planned how to control the variables they needed to keep the same. She couldn’t make decisions about the range and values of the independent variable as this was set by the mass of caffeine in the drink. They selected a stopwatch that allowed her to make a series of accurate measurements and Amy recognised the limitation of these and considered their reliability. She is also starting to consider validity by suggesting further enquiries to which her findings could be transferred. The pair made an ongoing revision to the method once they had recognised that Amy’s heart rate was remaining high and Amy gave simple justifications for her revisions. Amy used appropriate axes and scales for the line graph to show her data effectively, drew a line graph and offered explanations for possible anomalies. She explained her findings and changes to organisms using abstract ideas and recognised that a number of factors have to be considered when explaining changes in heart rate.
Within the topic of Particles, the class collaboratively drew a concept map about the particulate nature of solids, liquids and gases to assess their prior knowledge. The teacher asked pupils to rate themselves as ‘red’, ‘amber’ or ‘green’ as to their level of understanding. She put ‘greens’ in pairs with ‘ambers’ and they were given an extended response exercise from the Optional Assessment Materials, ACCAC 2001. The ‘reds’ were grouped together for her to teach. Amy is a ‘green’ as she feels confident in her knowledge.

Amy worked with Jon and their response shows that they used abstract ideas of particles including the particle model to describe the differences between solids, liquids and gases.

Amy’s next steps:
Read through your work and write three sentences to compare the particles in solids, liquids and gases.
Melting ice
Exploring enquiry

Skills
C2; ED3, 4, 7; ER4.

Range
TSE1.

To challenge them further, Amy and Ben were given a Thinking Card about changes of state to discuss and then report their findings back to the class.

<table>
<thead>
<tr>
<th>Changes of state</th>
<th>Thinking Card 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain, in terms of particles, what happens when an ice cube melts.</td>
<td>What would make the ice melt faster?</td>
</tr>
<tr>
<td>Where might your ideas be seen on the Earth?</td>
<td></td>
</tr>
</tbody>
</table>

Amy reported back:

For an ice cube to melt it’s given heat energy. The particles then have more energy. This energy means that they vibrate more and more and as they vibrate the forces between them get weaker. As the particles gain more and more energy the particles’ vibrations get bigger and bigger until they move apart. This is then liquid water. Ice would melt faster if it was given more heat energy. The particles would then have more energy quicker and so would move apart faster. An ice cube would melt faster if it was in smaller pieces as there would be more outside in contact with heat. Salt can be added to ice to make it melt faster – like grit on the roads. On Earth an increase in global warming may lead to the ice caps melting. The warmer the Earth and the air become the faster the ice caps and glaciers would melt.

Amy considered Jon’s ideas to inform her decisions. Again she used abstract ideas of particles this time to try and explain changes of state. However, links between the particles’ energy and the forces between them could be more detailed. She recognised that a number of factors would have an impact on the speed of melting, i.e. the rate of change of state. Amy linked the learning to the rate of ice caps melting due to global warming.
Once the teacher was happy that the class has an understanding of particles, she set them an enquiry on limestone. The pupils ‘brainstormed’ their ideas in groups before individually planning and carrying out their enquiry.

**Limestone enquiry**

Making things enquiry

**Skills**
C1, 2; EP1, 3; ED3, 4; ER1, 3, 4.

**Range**
TSE1, 2.

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**Limestone Enquiry**

Where could you find information to help you complete this project?

You could find information from books, the internet, quarry leaflets and posters, visits to a museum, a person who works in a limestone quarry, ask a classmate... and you can ask a science teacher or a scientist...

What do you think you will need to include in your presentation for it to have the required scientific detail?

You would need to include the different types of rock and how they are formed. You should also include the type of rock, limestone is also a type of chemical substance, e.g., calcium carbonate. You also need to describe the difference between elements, compounds, and mixtures to compare limestone with other substances. You would also need to make it more interesting so that people would read it...

How could you present your report on this project?

You could present your report on a leaflet form, a DVD, a poster, display and a booklet. We will make a flyer with charts and pictures...

You should now carry out the research for this project. Your completed report may be presented in any style you consider to be appropriate.

List the sources of information that you did use to complete your report below. I took my information from the Internet... There were many sites I went on, but the main one being rocksite... I checked the information with the RSC website... So it’s reliable...

Evaluate your success criteria:

I included the different types of rock and I showed where limestone fitted in to the sedimentary group. I made it interesting with pictures and I had enough information about how limestone is made up from the elements, calcium, carbon, and oxygen to make the compound. This would have improved the science...
Amy gave some justifications for her success criteria when questioned.

**Teacher:**
Why did you decide on these success criteria?

**Amy:**
People at Visitors’ Centres want to know the science. So I need to show how limestone has formed and maybe other rocks too. To do this properly I need to talk about elements and compounds and explain what they are. People at Visitors’ Centres will all know different amounts of science. So I need to keep it simple. Also I’d like to find out more!

Amy organised and communicated her findings as a flyer, which was fit for purpose and audience. She used abstract scientific knowledge to explain her findings, recognised that a number of processes have to be considered when explaining rock formation and evaluated how far her success criteria fully reflect successful outcomes. In doing so she set her own targets relating to the science involved in the flyer.

As part of the class’s reflection on their enquiry, they are asked to complete a table to identify the strategies they have used to learn.
Amy's next steps:
(written herself)
Look up how limestone is made up from the elements calcium, carbon and oxygen to make the compound.
Amy has identified the learning strategies she has used, and has started to link the learning to unfamiliar situations.
As part of a cross-curricular topic on volcanoes in Indonesia, with geography, Amy produced a poster to summarise her learning.

She used abstract ideas of energy transfer chains and changes and tried to quantify her predictions but did not manage to draw them to scale. Amy recognised that a number of processes have to be considered when explaining what happens in a volcanic eruption and linked the learning to unfamiliar contexts to produce the poster.

**Volcanoes**

Making things enquiry

**Skills**

C1, 2; EP1, 3; ED3, 4; ER1, 3, 4.

**Range**

TSE3; HTW2.

Amy’s next steps:

How does a volcanic eruption link to the rock cycle? You might like to look through your exercise book and then write a few sentences.
The class worked individually to apply what they have learned about energy changes and work done to a fictitious fairground ride.

**Amy** explains the changes in terms of work done and energy therefore recognising that a number of factors have to be considered when explaining changes. Some of her explanations also make links between energy and work done.

**Amy’s next steps:**
How could you calculate the work done when a person is at the top of the ride? Add this to your diagram.
Summary and overall judgement

Levels 5, 6 and 7 were considered and Level 6 was judged to be the best fit. Amy uses abstract ideas in her scientific explanations.

Planning

Amy’s profile shows that when planning an enquiry she can suggest a variety of methods or strategies for her enquiries (a characteristic of Level 6) as evidenced in several enquiries such as ‘Insulin presentation’. She makes predictions using abstract scientific ideas (a feature of Level 6) directly in ‘How does caffeine affect the heart rate?’ and indirectly in ‘Volcanoes’. In the latter enquiry she develops her own scientific ideas from prior knowledge and predicts comparative quantities of energies released from a volcanic eruption. In a fair test enquiry she plans how to control the variables that she needs to keep the same (a characteristic of Level 6), as is shown in ‘How does caffeine affect the heart rate?’. When Amy is asked to justify her success criteria (a feature of Level 6) she can, but doesn’t always develop her ideas fully. Therefore at times it could be said that she only gives some justification for her success criteria (a characteristic of Level 5).

Developing

When developing an enquiry Amy selects measuring instruments that allow her to make a series of accurate measurements (a feature of Level 5) as shown in ‘How does caffeine affect the heart rate?’ In this enquiry she regularly checks progress, makes ongoing revisions when necessary and is beginning to justify any amendments or improvements made (a characteristic of Level 6). Across her profile Amy organises and communicates her findings in a variety of ways fit for purpose and audience (a feature of Level 6) and this is especially evident in ‘Insulin presentation’. She uses appropriate axes and scales for graphs to show data effectively (a characteristic of Level 6) in ‘How does caffeine affect the heart rate?’. Her work shows that she is beginning to use some quantitative definitions (a feature of Level 6) in ‘Volcanoes’ although this is a target for her in ‘Fairground ride’. She considers reliability of information (a characteristic of Level 6) in ‘Insulin presentation’ and that of data in ‘How does caffeine affect the heart rate?’ In the latter enquiry Amy offers some explanations for anomalies when considering her findings (a feature of Level 6) even though she decides that she doesn’t really have any anomalous results. She uses abstract scientific knowledge and understanding, including models, when explaining her findings (a characteristic of Level 6) in enquiries such as ‘Insulin presentation’, ‘Solids, liquids, gases and their particles’ and ‘Limestone enquiry’.
Reflecting

She uses abstract scientific knowledge and understanding, including models, when explaining changes to organisms in ‘How does caffeine affect the heart rate?’; to materials in ‘Melting ice’ and to physical phenomena in ‘Volcanoes’ and ‘Fairground ride’; all aspects of Level 6 performance. Amy also recognises that a number of factors and/or processes may have to be considered when explaining changes (a feature of Level 6) in most of her enquiries. She is starting to make links between processes and systems (a characteristic of Level 7) as in the enquiries ‘Insulin presentation’ and ‘Fairground ride’. Amy considers a wider range of perspectives to inform opinions and decisions (a feature of Level 6) as evidenced in ‘Insulin presentation’.

Amy’s profile shows that when reflecting on an enquiry she is beginning to evaluate how far success criteria fully reflect successful outcomes (a feature of Level 5) in ‘Insulin presentation’ and ‘Limestone enquiry’. This isn’t a strength of Amy’s work as her justifications for her success criteria need to be more detailed. She identifies the learning/thinking strategies being used (a characteristic of Level 6) in ‘Limestone enquiry’. Throughout Amy’s profile there is evidence in several enquiries that Amy can link the learning to unfamiliar situations (a feature of Level 6).
Ben is a 14-year-old learner in Key Stage 3.

His teacher knows much more about Ben’s performance than can be included here. However, this profile has been selected to illustrate characteristic features of Ben’s work across a range of activities. Each example is accompanied by a brief commentary to provide a context and indicate particular qualities in the work.

Ben’s teacher judges that his performance in science is best described as Level 7.

The class have been studying Cells. The task about *Euglena* is part of an assessment for the teacher to decide if it is time to move onto the next topic.

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**Is *Euglena* a plant or an animal? Explain.**

Classifying and identifying enquiry

**Skills**

C2; ED3, 4; ER4.

**Range**

IO1.

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Ben applied the abstract ideas of, and made links between, cell structure and photosynthesis in his reasoning.
During the topic ‘Reactions’, Ben is asked to write down his ideas about respiration and combustion. He chose a previously used strategy (a two circled Venn diagram) to structure his ideas. He told the teacher that he chose this strategy as it worked well last time when he compared two different sections of a river in geography, which had some similarities and some differences. Therefore Ben gave some justification for the planned use of a Venn diagram by linking to work already undertaken in another subject.

Ben started by drawing a concept map to capture his ideas. He then transferred the information into a two circled Venn diagram. Both these strategies he chose himself. In the diagram he has compared the processes of respiration and combustion and made links between them.

**Respiration and combustion**

Pattern-seeking enquiry.

**Skills**

C2; EP1; ED3, 4; ER1, 3, 4.

**Range**

IO2, TSE3, HTW2.

**Ben’s next steps:**

Can you think of any other strategies that may also have worked here? Have a look at your Thinking Log for some ideas.
From the information in his Venn diagram Ben decided upon his success criteria, which he used to write a piece of continuous prose. On completion he self-assessed his prose by checking against his success criteria and then made suggestions for improvement.

Ben's next steps:
Look in your book at the work on Energy Transfers. Try to compare respiration and combustion in this way.
Ben used linked scientific knowledge and understanding gained from a variety of sources, including past work. He has started to refine his success criteria in the light of experience for future occasions by suggesting improvements to them. He reviews his strategy in light of his self-assessment by suggesting that he could use a three circled Venn diagram to compare these two processes with photosynthesis.

**Historical reactions**

Using and applying models enquiry

**Skills**

C2; ED3, 4, 7; ER4.

**Range**

IO7; TSE3, 5; HTW2.

Further into the topic of ‘Reactions’, the class was given information about historical scientific experiments. Each group had a different experiment. Ben’s group was given an experiment carried out by Joseph Priestley.

**Joseph Priestley found that a lighted candle in a jar soon went out. He put a plant in a jar and shone a light on it for a week. He found that the candle now burned for much longer**

The group was asked to think about how to explain the experiment and present their findings to the class.

**Conclusions**

- The candle burned (combustion)
  
  Fuel + oxygen → carbon + water + dioxide

- The plant photosynthesised
  
  Carbon + water → oxygen + glucose + dioxide

Joseph Priestley

Plant and candle experiment
Ben presented his group’s findings. He showed a good understanding in his presentation of how combustion and photosynthesis can act in a cyclical manner. He linked and applied abstract ideas not only of these processes but also he discussed fossil fuels and the greenhouse effect. He is starting to make predictions using his own explanations as to conditions on the Earth in the future. Therefore Ben is also linking his science learning to more abstract situations.

**Ben’s next steps:**
Again look at Energy Transfers and compare combustion, respiration and photosynthesis.
Still within the ‘Reactions’ topic, the class have moved on to learn about displacement of metals. They are planning to carry out an investigation into the temperature change when magnesium and copper sulphate react.

How does the mass of magnesium added affect the temperature rise in its reaction with copper sulphate?

Fair test enquiry – (predicting only)

Skills C2; EP2, 4.
Range TSE4.

Ben made qualitative predictions using linked scientific knowledge and understanding gained from a variety of sources including past work on exothermic reactions and his observations of the teacher demonstration. With direct teacher questioning he could have made this a quantitative prediction. He also realised that although he was measuring the temperature rise, this variable would have an influence on the rate of reaction and he explained his reasoning. In this way he is identifying a key variable that may not be readily controlled and explaining why this is the case.

You have observed the reaction between magnesium metal and copper sulphate solution. How do you think that the mass of magnesium added will affect the temperature rise in this reaction?

**Prediction**
The greater the mass of magnesium metal the higher the temperature rise will be. I think there will be a point when the temperature rise is at a maximum because all the copper sulphate has reacted.

**Why does this happen?**
This is an example of a displacement reaction. A displacement reaction is one where a metal is more reactive than one in a salt so it takes its place. In this reaction magnesium is more reactive than copper so it will take copper’s place in the copper sulphate. The word equation is:

$$\text{copper} + \text{magnesium} \rightarrow \text{magnesium} + \text{copper sulphate}$$

This reaction is an exothermic reaction. As it occurs it gives off heat energy.

So the more magnesium used the more displacement reactions can happen, more heat energy will be given out and so the greater the rise in temperature. But this will only be to a point when all the copper in the compound has been replaced with magnesium. On a graph the line would level out at this point. The problem that I might have will be with the surface area of the magnesium metal as it won’t be easy to keep this the same. If there is more magnesium in contact with the copper sulphate then more displacement reactions can take place at the same time. I think this will mean that the temperature will rise faster but it should still reach the same highest temperature as the same amount of copper sulphate is used each time.

**Ben’s next steps:**
Can you think of any ways in which these key variables could be controlled? You might like to think about links to other situations.
Within the topic of ‘Space’, Ben’s class studied the space shuttle. Part of this work included trying to predict how a space shuttle lands. They had already studied the flight of an aeroplane.

How does a space shuttle land?

Using and applying models enquiry

Skills
C1, 2; EP2, 3; ED3, 4; ER4.

Range
HTW2, 3, 4.

How does a Space Shuttle land?

Think about and discuss in pairs how a space shuttle comes down from orbiting the Earth to land.

© NASA Space Shuttle Endeavour

The space shuttle orbits the Earth travelling at high speeds and held in orbit by gravity (gravitational pull to the Earth). It slows down and moves itself out of orbit so that it can come down to Earth. The weight of the shuttle pulls it down towards the Earth as this force is greater than the other forces acting on it. As the shuttle enters the atmosphere it is travelling so fast that some of its kinetic energy is converted to heat energy. Also it is constantly being hit by air particles at very high speed so this kinetic energy is converted to heat energy. As it speeds up it has more collisions with more air particles more often giving more heat energy. The shuttle needs to have a very strong covering of an insulating material to stop it from burning up on re-entry.

It needs to slow down very quickly when it lands so when it has landed it releases a parachute to slow down the forward movement caused by its engines. Because it’s like an aeroplane it could put its engines into reverse to reduce the wear on the brakes. As the shuttle moves forwards the air tries to stop it. This is air resistance, a sort of friction. The air particles are being hit by the shuttle which slows it down. Because the parachute is open there is more air resistance to slow down the shuttle. This is because there is more surface area in contact with the air particles. Friction is also caused as the tyres move across the ground this also slows down the shuttle.

Ben’s next steps:

Review your work and try to look at the forces involved in each situation. How do they compare? Use your work on flight to help you.

Originally in his prediction of how a space shuttle lands, Ben applied abstract ideas and made links between physical phenomena. These included air resistance, kinetic energy converted into heat energy and the need for insulation to stop the shuttle burning up. He took these ideas further with research and redrafting so that he could explain how the space shuttle reduces its speed of descent to reduce the heat energy from collisions with air particles.
In the topic ‘Energy and Work done’ the class are given an enquiry to assess their understanding.

**Work done**

Look at the list of events below.
- You climbing to the top of Snowdon
- An Asian elephant walking 400m
- A new mini car travelling 5km
- You pushing against a brick wall for 30 minutes
- The Orbiter of the space shuttle taking off and reaching space
- You lifting a box from the floor to your desk
- The Moon buggy travelling 200m during the Apollo 17 Moon landing

Put the events in order with the most work done at the top and the least at the bottom. Discuss your decisions with a partner and come up with a consensus view.

| Event Description | Estimate
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbiter...taking off...to space...</td>
<td>millions J</td>
</tr>
<tr>
<td>Moon buggy...</td>
<td>hundreds of thousands J</td>
</tr>
<tr>
<td>Elephant...walking...</td>
<td>thousands J</td>
</tr>
<tr>
<td>You pushing...</td>
<td>hundreds J</td>
</tr>
<tr>
<td>Lifting a box...</td>
<td>10 J</td>
</tr>
<tr>
<td>Pushing against a brick wall...</td>
<td>0 J</td>
</tr>
</tbody>
</table>

What evidence could you use to support your decisions?

**Note down the reference sources you use.**

- Work estimated...the work done to put...in order. Then we used...an internet search...in...the...work done...force...distances...5km...5.60...800m...

\[
\text{work done} = 6.10 \times 10^6 \text{J}
\]
2. Mini cent...mass...160g...3m...20N

3. Elephant...mass...6000kg...7.0m...20N

4. Mr. Snowdon...mass...62kg...3.8m...120N

5. Moon buggy...mass...283kg...2.0m...800N (Earth)

6. Can't calculate this, but a light box has a mass of about 1kg...10N of force...t's about 1m from floor...at rest...

7. Pushing against a brick wall...the box is...

So, we put them in the right order...but...
Ben and his partner ranked the events and recognised that pushing against a brick wall does not constitute work done. They selected the strategy of estimation and calculated the work done in each event – using quantitative definitions and performing calculations using the correct units. However, the resultant force in the examples where the motion is horizontal could not be calculated by using weight. Therefore this shows only a partial understanding of the concept of work done. They have begun to evaluate their findings in order to gauge bias, reliability and validity. Although they haven’t actually described how they might collect more information in order to check the validity of their conclusions they have recognised the need to do so.

**Ben’s next steps:**

Draw a flow chart to show the strategies you have used in your Thinking Log. Could you have used any others?

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Evaluate the reference sources, looking at bias, reliability and validity.
Summary and overall judgement

Levels 6 and 8 were considered and Level 7 was judged to be the best fit.

Ben enjoys applying scientific ideas in new and novel ways. He applies his number skills in a variety of ways in science. Given challenging, rich tasks he excels.

Planning

Ben’s profile shows that when planning an enquiry he can suggest a strategy (a feature of Level 6) in ‘Can you work out work done?’ Here he estimates before calculating his answers but gives no justification for doing so. He gives some justification for the strategy he plans to use (a characteristic of Level 7), in ‘Respiration and combustion.’ He chooses to use a Venn diagram as he recognises that there are common elements in the two processes. He makes qualitative predictions using linked scientific knowledge and understanding gained from a variety of sources (a feature of Level 7) as evidenced in ‘How does the mass of magnesium added affect the temperature rise in its reaction with copper sulphate?’ In the planning of this enquiry he also identifies a key variable that may not be readily controlled explaining why this is the case (a characteristic of Level 7).

Developing

When developing an enquiry Ben uses some quantitative definitions and performs calculations using the correct units (a feature of Level 7) in ‘Can you work out work done?’ Had his ideas been further developed with focused questioning in ‘How does the mass of magnesium added affect the temperature rise in its reaction with copper sulphate?’ he could have evidenced making quantitative predictions using detailed scientific knowledge and understanding (a characteristic of Level 8). In the former enquiry he is beginning to evaluate his findings in order to gauge bias, reliability and validity (a feature of Level 7), and although he hasn’t actually described how he might collect more information in order to check the validity of their conclusions (a characteristic of Level 7), he has recognised the need to do so. Ben applies abstract ideas and makes links between processes or systems in explanations (a feature of Level 7) in several enquiries, such as in ‘Is Euglena a plant or an animal? Explain where he makes links between cell structure and photosynthesis. Also in
‘Historical reactions’ he applies and links the abstract ideas of photosynthesis and combustion and in ‘How does a space shuttle land?’ he applies and makes links between air resistance, kinetic energy and insulation. In ‘Historical reactions’ Ben begins to use his explanations to make predictions (a characteristic of Level 7) on the future of the Earth in the contexts of fossil fuels and the greenhouse effect.

**Reflecting**

When **reflecting** on an enquiry Ben refines his success criteria in the light of experience for future occasions (a feature of Level 7) as evidenced in ‘Respiration and combustion’. In the same enquiry he reviews his strategy (a characteristic of Level 7) and suggests how to amend it to suit a slightly different and more complex task. He links the learning to more abstract situations (a feature of Level 7) across his profile, for example in ‘Historical reactions’ as he develops his ideas on fossil fuels and the greenhouse effect and could be said to be linking the learning to make further predictions (a characteristic of Level 8).
Useful information and websites

Materials developed by or in conjunction with DCELLS

Skills framework for 3 to 19-year-olds in Wales

National curriculum Orders

Developing thinking and assessment for learning programme (WAG)

- Why develop thinking and assessment for learning in the classroom
- How to develop thinking and assessment in the classroom
- Developing thinking and assessment for learning poster

All these materials are available from the ‘Curriculum and assessment’ section at: www.wales.gov.uk/educationandskills

Aiming for Excellence: Developing thinking (BBC, Estyn, WAG) 2006
A coaching/training DVD pack.

Other useful references with websites

King’s College London

- The ASE – King’s Science Investigation in Schools Project (AKSIS)
  www.kcl.ac.uk (search for AKSIS)
- Cognitive Acceleration through Science Education (CASE)
  www.kcl.ac.uk (search for CASE)
- SKEES Project (Science Enhancement Programme – King’s Enhancing Enquiries in Schools)
  www.kcl.ac.uk (search for SKEES)
- Talking to Learn, Learning to Talk in Secondary Science
  (ESRC: Principal Investigator: Professor Jonathan Osborne, King’s College, London)
  www.kcl.ac.uk (Search for talking to learn)

The University of York (Nuffield Curriculum Centre)

- 21st Century Science
  www.21stcenturyscience.org

Encouraging experimentation and investigation in school science learning (NESTA) – Real Science
www.nesta.org.uk (search for Real Science)
Other publications

*Improving teaching and learning in schools* (TLRP, ESRC) 2006

*Science Education in schools, Issues, evidence and proposals* (TLRP: Gilbert, J (Ed)) 2006

*Science Inside the Black Box* (Bethan Marshall, Jeremy Hodgen and Chris Harrison)
ISBN: 9780708714447/N0078

*Scientific Enquiry materials* (Cripsat, University of Liverpool) 2007 sponsored by WAG
ISBN: 978-0-9557200-1-7
www.cripsat.org.uk

*The role of teachers in the assessment for learning* (E) (Nuffield Foundation: Harlan et al) 2006
www.k1.ioe.ac.uk
Acknowledgements

The Department for Children, Education, Lifelong Learning and Skills (DCELLS) would like to thank the many teachers, schools, local authorities and other organisations who have helped in the development of this guidance.

Special thanks are given to Margaret Robertson (Cynnal) for her invaluable assistance and to the Guidance Group, Dr Helen Baker, Elfed Charles, Bryan Jenkins, Catherine Jones, Helen Woodford, Rhian Pugh, Alun Williams, Clive Thomas, who gave up valuable time to assist us in the development of this guidance.

DCELLS would also like to thank those pupils and parents/guardians who agreed to allow examples of work to be reproduced in this guidance.

In particular, DCELLS is grateful to the following schools for providing help and materials:

Welshpool High School, Powys
Ysgol Botwnnog, Gwynedd
Ysgol Bro Gwydir, Conwy
Ysgol Brynrefail, Gwynedd
Ysgol Gyfun Bro Morgannwg, Vale of Glamorgan
Ysgol Gyfun Cwmtawe, Neath
Ysgol Gyfun Gartholwg, Rhondda Cynon Taff
Ysgol Gyfun Gymraeg Bryntawe, Swansea
Ysgol Gyfun Llangefni, Anglesey
Ysgol Pen-y-bryn, Gwynedd
Ysgol Syr Hugh Owen, Gwynedd
Ysgol Syr Thomas Jones, Anglesey.

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