Skills development within the sciences

Stranraer Cluster

Dumfries & Galloway Council

Skills development within the sciences

The experiences and outcomes in science provide opportunities for children and young people to develop and practise a range of inquiry and investigative skills, scientific analytical thinking skills, and develop attitudes and attributes of a scientifically literate citizen; they also support the development of a range of skills for life and skills for work, including literacy, numeracy and skills in information and communications technology (ICT).

These skills are embedded in the contexts detailed in the experiences and outcomes. The progressive development of these skills throughout the levels is supported through the increasing complexity of the scientific contexts and concepts being developed and through revisiting and reinforcing the skills.

Inquiry and investigative skills

Through experimenting and carrying out practical scientific investigations and other research to solve problems and challenges, children and young people:

- ask questions or hypothesise
- plan and design procedures and experiments
- select appropriate samples, equipment and other resources
- carry out experiments
- use practical analytical techniques
- observe, collect, measure and record evidence, taking account of safety and controlling risk and hazards
- present, analyse and interpret data to draw conclusions
- review and evaluate results to identify limitations and improvements
- present and report on findings.

The main approaches to science inquiry are:

- observing and exploring – careful observation of how something behaves, looking for changes over time and exploring 'what happens if...?' and 'how could I...?' questions
- classifying – through identifying key characteristics
- fair testing – through identifying all possible variables and then changing only one while controlling all others
- finding an association – linking two variables to determine relationships.

Scientific analytical thinking skills

Children and young people develop a range of analytical thinking skills in order to make sense of scientific evidence and concepts. This involves them:

- being open to new ideas and linking and applying learning
- thinking creatively and critically
- developing skills of reasoning to provide explanations and evaluations supported by evidence or justifications

- making predictions, generalisations and deductions
- drawing conclusions based on reliable scientific evidence.

Skills and attributes of scientifically literate citizens

Children and young people develop as scientifically literate citizens with a lifelong interest in science by:

- developing scientific values and respect for living things and the environment
- assessing risk and benefit of science applications
- making informed personal decisions and choices
- expressing opinions and showing respect for others' views
- developing informed social, moral and ethical views of scientific, economic and environmental issues
- developing self-awareness through reflecting on the impact, significance and cultural importance of science and its applications to society
- demonstrating honesty in collecting and presenting scientific information/data and showing respect for evidence
- being able to read and understand essential points from sources of information including media reports
- discussing and debating scientific ideas and issues
- reflecting critically on information included or omitted from sources/reports including consideration of limitations of data.

The experiences and outcomes clearly indicate opportunities for developing these skills and attributes.

Progression within the skills

Throughout the framework, these investigation and cognitive skills are signalled within the experiences and outcomes across all levels. The skills become more complex as learners' conceptual understanding develops within increasingly complex science contexts.

Teachers can plan to focus on the development of specific skills through investigations, inquiries or challenges, with occasional opportunities for more detailed and comprehensive activities, recognising that any one investigation does not always require children and young people to develop the full range of skills.

Early Level

At early level the stimulus for investigating comes from play experiences supported by exploring available resources such as books, pictures, signs, charts, the internet and media clips. Learners share their thoughts and ideas, raise questions and make predictions. Learner planning includes considering possible ways to proceed and making decisions about the steps to be carried out. Early level practical activities are based on exploration through play and the gathering of information including through their senses. Learners begin to consider risks associated with specific activities and take steps to ensure their own safety and that of others.

Learners typically present their findings in the form of photographs, video clips and drawings and provide oral descriptions and explanations of what they did and what happened. Learners are supported to look for connections, patterns, similarities and differences in the findings and to make links with their original question. Learners are encouraged to comment on the ways in which what they have found out answers their question and how their findings relate to their everyday experiences.

At early level learners build on their natural curiosity to develop skills of analysis by exploring, for example, how things work. They draw on what they learn in the sciences to think creatively, providing suggestions

and solutions to everyday problems. They develop skills of reasoning and provide explanations for their choices and decisions. Learners develop respect for living things and their care and for the environment.

First Level

At first level learners contribute to investigating as a member of a collaborative group. The stimulus for investigating leads to discussion of the specific scientific concept, idea or issue to be explored. Learners collaborate with others to observe, collect information and make measurements using appropriate equipment and units. They identify specific safety issues and respond appropriately to reduce the potential of harm to themselves and others.

Learners select appropriate forms of presentation for the data and information they have gathered. They construct tables of data, charts and diagrams of various kinds, using labelling and scales where appropriate, and from these identify significant patterns and relationships. Presenting the data/information assists learners in their interpretation and leads to discussion of the extent to which the question being explored has been answered. Learners identify limitations of their investigation and therefore improvements they might make. They will convey their findings orally, visually and in writing using a variety of media. They will progress from responding to questions provided to support their presentations to structuring their presentation in a coherent and logical way.

At first level learners apply their learning in the sciences and provide creative solutions to scientific issues and problems. They contribute to the design process including combining components to make models. They develop their reasoning skills, drawing on their knowledge and understanding of scientific concepts to make and test predictions and provide explanations supported by evidence. Children should make connections between science and their own health and wellbeing.

Second Level

At second level learners investigate more independently and formulate questions and predictions based on observations and/or on information they have gathered. In designing procedures they identify the significant variables, decide which one to vary, which to control and which to observe or measure. Learners continue to gather information from observations, extend the range of measuring techniques, units used and equipment, including digital multimeters, sensors and dataloggers. Learners ensure safe use of all tools, equipment, apparatus and procedures.

Learners have an extended range of presentation methods, including bar and line graphs, from which they can select the most appropriate for presenting the data/information they have collected. They identify the relationship between the variables and use this to draw an appropriate conclusion, consistent with the findings. They will work individually and with others to collate, organise and communicate their findings. They select ideas and relevant information, organising and combining these in an appropriate way for a particular audience, using suitable scientific vocabulary. They recognise the need to acknowledge their sources and do this appropriately. They summarise the main points of their findings; beginning to develop scientific report writing skills using appropriate headings and question prompts to presenting their findings.

At second and third levels learners apply their understanding of science concepts to solve problems and provide solutions. They further develop their creative thinking including through the engineering process, designing, constructing, testing and modifying their solutions. Learners progress in their scientific analytical thinking skills through working with increasingly complex contexts that require them to analyse, synthesis and integrate their learning in the sciences. By second level they develop their understanding of the relevance of science to their future lives and become increasingly aware of the role of science in different careers and occupations.

Third Level

At third level learners, in a specific context, use observations, information and their own knowledge and conceptual understanding to identify key questions. Having formulated hypotheses and predictions, they design procedures to test a hypothesis requiring the control of an increased number of more complex variables. They show initiative and increasing independence in the decisions they make in relation to all aspects of a practical activity. The data and information collected are more extensive and more complex and include information collected using data logging equipment. There is increased precision in the use of scientific terminology and in the use of measurement, scales and units. Learners use their knowledge and experience to anticipate and apply safety measures to control all risks and hazards associated with the practical activity.

Learners present data and information in a number and variety of ways. This supports interpretation and analysis leading to learners establishing the relationship between variables and to the examination of links to the original question, prediction and/or hypothesis. Learners use their

understanding of scientific concepts to explain the findings in terms of cause and effect. Evaluation of a range of aspects of the investigation or inquiry by the learner includes consideration of the relevance and reliability of the data and information collected. Learners begin to consider alternative explanations and identify further studies which might clarify the relationship or provide further evidence to enable greater reliability. They present findings of their research, investigation or inquiry in a coherent and logical way, using scientific language appropriate to third level. They select the appropriate mode and format of presentation of their work for the purpose suitable for its audience. They recognise when it is appropriate to quote from sources and acknowledge sources appropriately. In presenting their findings, they include relevant supporting detail and/or evidence.

At third level they increasingly develop their awareness of creativity, inventiveness and the use of technologies in the development of the sciences, understand the impact of science on society and discuss the moral and ethical implications of some developments.

Dumfries & Galloway Progression & Achievement Frameworks

The Dumfries & Galloway Progression and Achievement Frameworks have been created to support all practitioners in the planning, delivery, assessment and moderation of science. Further details around core knowledge progression within science can be found within these frameworks, available on GLOW.

Inquiry and Investigative Skills

Investigating involves learners in using procedures such as planning, observing, measuring, analysing and evaluating as well as more general skills such as decision making and communicating findings. The evidence should demonstrate skills of scientific inquiry and these skills may be assessed through a range of approaches.

Ask questions

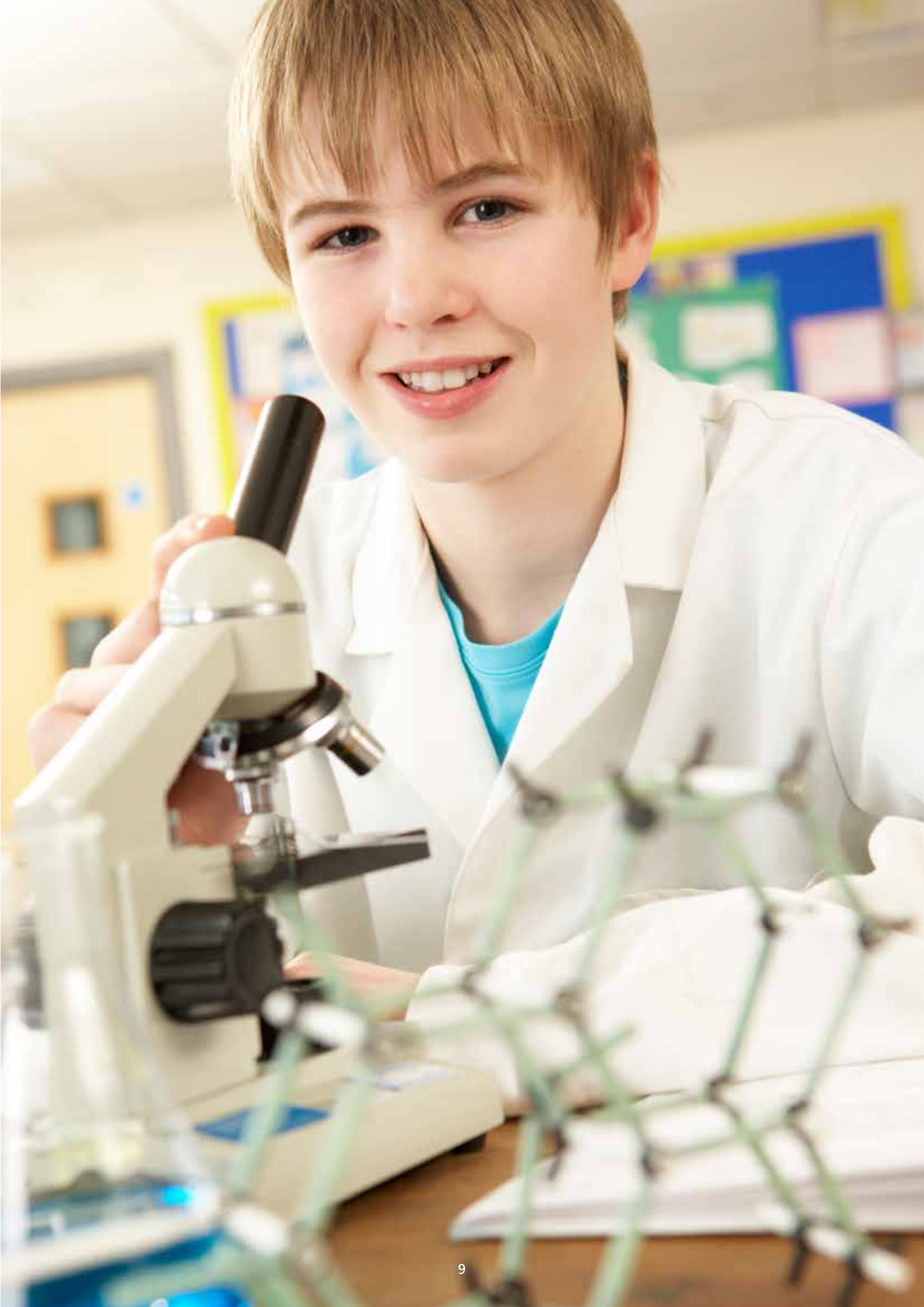
Early	First	Second	Third
I ask questions about events, objects, things I have explored and show curiosity)	I ask questions and (with help) suggest what I will do to answer it	I formulate questions which can be tested, based on observations and information	I can identify a range of key questions to be tested based on knowledge or observations I have made.
I make suggestions for investigations (on how to answer a question)	I ask questions that can be investigated and I can say whether I need a fair test to answer it.	I ask questions and decide the type of enquiry needed to answer it (observe, explore, classify, fair test, find an association	
I ask questions using a range of question stems eg How? What will happen if? Why?			

Hypothesise/Predict

Early	First	Second	Third
I have an idea of what might happen	I can make simple predictions	I can make predictions which are beginning to be based on my scientific understanding	I can make predictions and use scientific knowledge to explain and justify my prediction.
I can make a simple prediction	I can predict the order of results	I can use my scientific knowledge and understanding to explain and justify my prediction.	I can predict the direction of the relationship between variables.
	I can give everyday reasons for my predictions	I can sketch a graph to show the expected pattern of results	

Plan and Design Procedures and Experiments

Early	First	Second	Third
I can suggest why a test is obviously not fair.	I help to plan simple investigations.	I can plan a fair test.	I can identify the variable being changed (input variable) and explain which variables should be controlled (controlled variables).
I can sometimes suggest next steps in a plan.	I can explain how to make a fair test.	I show an awareness of the variables to be controlled (kept the same) and those which could be changed	I am confident dealing with more complex variables.
I can work out what I am changing in the investigation.	I can explain why a test is fair, and identify when a plan will lead to an unfair test.	I can identify the variable to be measured or observed in order to collect my results	I am aware that there may be several variables which could be measured to determine the effect of the input variable and, with support, identify the most appropriate.
I know what will be measured/observed in the investigation.	I can state why fair tests are needed and can identify the variable/factors to be changed.	I can identify all or most of the variables/ factors that should be kept the same.	
	I can identify the variable/factor to be measured/observed.	I can discuss the effect of sample size on the reliability of results.	I can include effective control groups in my experiment.
	I can list most of the variables/factors that should be kept the same		



Select appropriate samples, equipment and other resources

Early	First	Second	Third
I can choose appropriate equipment from a limited range, with support. I understand the need to take more than one sample to compare the results.	I can choose appropriate equipment from a wider range. I understand the need to take more than one sample, and repeat readings, to obtain valid results.	I can choose appropriate equipment from a wide range, taking into account the scale and degree of accuracy required of measuring equipment. I understand the need to have at least three samples, and repeat readings, to identify the pattern/trend.	I can choose appropriate sampling strategies to produce a range of results which would relate to the aims of the experiment. I am beginning to understand the need for independent replication to increase the reliability of results.

Carry out experiments

Early	First	Second	Third
With support, carry out the planned experiment.	With increasing independence, carry out experiments, following the plan. Teacher observations would confirm appropriate equipment, variables, measuring & recording.	With independence, carry out planned experiments accurately using a range of equipment. Teacher observations would confirm appropriate equipment, variables, measuring & recording.	I can plan a practical investigation giving an aim, testable hypothesis and methods which reflect my understanding of good scientific procedures. I can make decisions about sampling intervals, accurate measurements and replication which allow me to test the aim in a scientific manner.

Use practical analytical techniques

Early	First	Second	Third
I can try out different approaches.	I can identify questions that can be answered by trying it out and those that cannot. I know there are different ways to answer scientific questions.	I know when to answer a question by using a fair test and when evidence should also be collected in other ways, including using secondary sources. I can identify an appropriate approach to answer a scientific question.	I can increasingly take the initiative in designing and planning practical experiments to investigate a scientific question. I can plan an investigation which clearly sets out an aim and a testable hypothesis. I can plan using good scientific procedure - controlling variables, sampling accurately and effectively and undertaking replication to increase validity.

Observe, collect, measure and record evidence, taking account of safety and controlling risk and hazards

Early	First	Second	Third
I can observe simple experiments and changes that happen I know how to use the measuring instrument my teacher gives me. I know at least two different measuring units for length, time, volume and weight. I can complete a pre-prepared simple table or chart.	I can make relevant observations and can start to recognise patterns or trend I can choose a measuring instrument from a selection and know how to use it correctly. I know to repeat my measurements. I know at least two different measuring units for length, time, volume, temperature, weight and mass. I can complete a table with extra columns for repeat measurements. I can put in most of the headings and units.	I can observe changes over time I can suggest a suitable measuring instrument to use and I know how to use it. I can use a variety of different units for measurements and I can perform some simple calculations e.g. I can calculate an average from my repeat measurements I can draw my own table with columns for repeat measurements and an average. I can put in the correct headings and units. I can draw bar graphs and line graphs correctly, on my own, and can identify which is appropriate using knowledge of discrete and continuous data sets.	I can suggest ways to recorded results accurately and, where appropriate, use data loggers and software analysis tools to support this. I can choose appropriate tables and graphs to present data, using the correct units and scales.
Safety I know how to keep myself and others around me safe.	Safety I am beginning to recognise hazards and know how to keep myself and others around me safe.	Safety I can assess hazards and risks and can plan how to control these to keep myself and others around me safe.	Safety I am confident considering risks associated with procedures and can suggest safety measures which will minimise those risks.
Classifying I am able to sort a small number of items into groups with obviously different key characteristics.	Classifying I can sort things into groups using a variety of different characteristics.	Classifying I can sort things into groups and explain the reasons for my choice. I can recognise if something does not fit into one of my sorted groups and explain why.	

Present, analyse and interpret data to draw conclusions

Early	First	Second	Third
I can describe my observations. I can answer questions about my results using what I changed, and what I measured to help me.	I can talk about my results on my own or as part of a group. I can talk about the effect one variable had on the other variable.	I can explain my results on my own using the investigation variables and correct scientific language. I can draw conclusions which are directly related to my findings. I can use a variety of evidence to answer my investigation. I can relate my findings to scientific knowledge.	I can choose appropriate tables, charts or graphs to present data, using the correct units and scales.
Finding Associations I can identify links between the change made and the effect in a simple experiment. I can look back at my results and say whether my prediction was correct or not	Finding Associations I can explain what I found out in terms of my original prediction, and say whether what happened was expected. With support I can make further predictions based on these results or patterns.	Finding Associations I can confirm if my prediction was correct and if not, I can formulate a conclusion which is based on the evidence of the changes recorded in the results. I can make further predictions from these results and use these to test out my findings	Finding Associations I can establish whether a relationship exists between the input and outcome variables using data as evidence. I can relate these findings to the original aim and hypothesis or prediction.

Review and evaluate results to identify limitations and improvements

Early	First	Second	Third
With support I can recognise some of the difficulties or successes encountered.	I can recognise some of the difficulties encountered and suggest how these might be avoided and the investigation improved.	I can identify what I did to make the results reliable or suggest ways to make the results more reliable.	I can evaluate the relevance of the investigation and suggest improvements.
I can say if my investigation needs improving and why.	I can recognise some of the successes encountered.	I can identify what I did to make the results accurate or suggest ways to make the results more accurate.	I can evaluate the reliability of the investigation and suggest improvements.
	I can suggest one way of improving my investigation.	I can discuss how much to trust the results and justify my decisions in relation to the control of variables and whether it was a fair test.	I can assess the quality of evidence based on knowledge of good research practice.
	I can identify one aspect of my investigation which helped make sure the results were valid.	I can discuss how much to trust the results and justify my decisions in relation to how many results were collected and if the repeat experiments followed the same trend.	I can explain the findings in terms of cause and effect.
		I can suggest reasons why similar investigations may yield different results.	I can explain the findings using my understanding of the underlying scientific concepts.
		I recognise the limitations of the evidence gathered.	I can consider alternative explanations for my findings.
		I know that different people may interpret evidence in different ways.	I can suggest further studies to extend the conclusions.
		I can suggest two or more ways of improving my investigations.	

Present and report on findings

Early	First	Second	Third
I can use drawing to present evidence. I can use a pictogram. I can complete a pre-prepared bar graph with scales, units and axis labels. My report can be written or spoken. I can put a list of what I did in the investigation in the correct order. I can draw a diagram of the equipment. I can say what I found out.	I can use drawings and labels to present evidence. I can draw a bar graph correctly on my own. I can complete a pre-prepared line graph with scales and axis labels. My report can be written or spoken. It will have: • A plan of my fair test and my predictions • Equipment list, diagram, and a few sentences on how I carried out the fair test. • Results table and graph • What I found out and why I think that happened.	I can draw bar graphs and line graphs correctly, on my own, and can identify which is appropriate using knowledge of discrete and continuous data sets. My report can be written or spoken. It will have: • An aim, predication or hypothesis. • Labelled diagram and an explanation of how I carried out a fair test. • Results table and graph • My conclusions related to the investigation question. • An evaluation on the methods I used and how valid the results are. I will start to depersonalise my writing (written in 3rd person, past tense & narrative).	I can write a scientific report that includes the following: Aim Hypothesis or prediction Method, including the input, outcome and control variables (labelled diagram if appropriate) Results in an appropriate form of table, chart, diagram or graph using suitable scales. Analysis including a description of any relationship between the variables Conclusion that establishes the link between the findings and the original aim/ hypothesis/prediction Evaluation I can present my findings for audiences including adults from out with the school I can provide supporting evidence and quotes and acknowledge sources

Scientific and analytical thinking skills

Learners progress in their scientific analytical skills through opportunities to develop these in a range of contexts. These include practical and research-based investigations and inquiries which can generate data and information either produced by the learners themselves or from given or researched sources. Developing scientific analytical thinking skills in the context of Planet Earth, Forces, electricity and waves, Biological systems, Materials and Topical science helps learners develop a depth of understanding of the underlying science concepts.

Early	First	Second	Third
I am curious and ask questions about the world around me.	I can make connections between what I know and the skills I have to solve scientific problems	I can connect my learning and apply the knowledge and skills I have in new and more complex concepts.	
Using what I know I can make suggestions to explain what I observe	I can contribute to the design of a model choosing different components. Eg. Mars rover, model of a cell, electrical circuit	I can solve problems and provide solutions using logic and applying my knowledge and understanding	
I can offer solutions to everyday problems and explain my choices and decisions	I use logical thinking to make and test my predictions	I show creative thinking in inquiry and investigative skills: designing, constructing, testing and modifying	
	I use evidence to explain my thinking and conclusions	I can present an informed view both orally and in writing	
		I can present a reasoned argument which is based on evidence and demonstrates my knowledge and understanding of the topic	

Scientifically Literate Citizens

As learners progress as scientifically literate citizens, they recognise the impact science makes firstly in relation to themselves and upon their everyday life, progressing to understanding the impact science has on the environment and society. Through debate and discussion which take account of relevant science concepts and ideas, they express their opinions, develop informed views on an increasing range of social, moral, ethical, economic and environmental issues.

Early	First	Second	Third
I am beginning to talk about science	I can discuss how developments in Science affect my life	I can explain the relevance of science to my future life	
I can show respect and care for living things and the environment	I can make connections between Science and my own Health and Wellbeing.	I am increasing my knowledge and understanding of the range of careers and occupations involving science	
I can talk about science in the world around me	I am aware and can talk about how people use science in their job roles and careers.	I am aware of how creativity and inventiveness are important aspects of science, and can give examples of new technologies having an impact of science in society	
I have talked with, or found out about, people who use science in their job	I can discuss science topics in real life contexts including media.	I can identify and discuss misuse of science in society eg in advertising, political lobbying & journalism.	
	I can talk about my own impact on the world.	I can critically assess the use of science in a local planning decision eg flood defences, farm development, forest management.	
		I can express informed views based on evidence about scientific and environmental issues in the wider world	

Assessment of skills

From the early years through to the senior stages, children and young people will demonstrate progress through their skills in planning and carrying out practical investigations, inquiries and challenges, working individually and collaboratively, and describing and explaining their understanding of scientific ideas and concepts. They will also demonstrate evidence of progress through their abilities and skills in reasoning, presenting and evaluating their findings through debate and discussion, expressing informed opinions and making decisions on social, moral, ethical, economic and environmental issues.

Approaches to assessment should identify the extent to which children and young people can apply these skills in their learning and their daily lives and in preparing for the world of work. For example:

- How well do they contribute to investigations and experiments?
- Are they developing the capacity to engage with and complete tasks and assignments?
- To what extent do they recognise the impact the sciences make on their lives, on the lives of others, on the environment and on society?

Children and young people will demonstrate their progress through investigations, inquiries and challenges, and through how well they apply scientific skills in increasingly complex learning situations. For example, investigations and inquiries will become more evaluative, deal with an increasing range and complexity of variables, and involve collecting and analysing increasingly complex information.

Through developing these skills, children and young people will demonstrate growing confidence and enjoyment of the sciences. Assessment should also link with other areas of the curriculum, within and outside the classroom, to allow children and young people to demonstrate their increasing awareness of the impact of scientific developments on their own health and wellbeing, society and the environment.

What do breadth, challenge and application look like in the sciences?

Well-planned learning, teaching and assessment provide opportunities for learners to experience breadth, challenge and application in the sciences.

Breadth

Learners demonstrate their achievements in the significant aspects of learning in the sciences in relation to:

- A range of learning in the sciences across Planet Earth, Forces, electricity and waves, Biological systems, Materials and Topical science
- A range of investigations and inquiries to develop understanding of underlying scientific concepts and awareness of themselves and the world
- Using a wide range of scientific language, formulae and equations in descriptions and explanations of scientific concepts
- Expressing informed opinions and making decisions about a range of social, moral, ethical, economic and environmental issues.

Breadth provides learners with opportunities to draw on their own experiences and interests in the sciences to bring relevance to the learning. A range of stimuli for learning are explored, including books, pictures, charts, the internet and media clips. Approaches to learning in the sciences include a range of practical and research-based investigations and inquiries such as observing, exploring, classifying, sequencing and sorting, fair testing, and making associations. Learners have opportunities to discuss and debate sciences in terms of assessing potential benefits and risks.

Challenge

Opportunities for challenge allow learners to:

- Demonstrate understanding of increasingly complex scientific contexts and concepts
- Develop a range of scientific analytical thinking skills in order to make sense of scientific evidence and concepts
- Become increasingly evaluative, providing more detailed explanations based on more complex evidence and understanding of underlying scientific concepts.

Learners engage in increasingly complex tasks and assignments including investigations and inquiries with increasingly complex, or a greater number of, variables. Learners respond with increasing accuracy and confidence when working with more complex scientific concepts in context. Using open-ended tasks and assignments provides opportunities for learners to become increasingly independent, taking the initiative in decision making and justifying decisions. Learners use increasingly complex procedures, techniques and equipment, and analyse increasingly complex information.

Application

Learners link and apply their scientific knowledge and understanding and skills to new and unfamiliar contexts by:

- Analysing and interpreting evidence to draw conclusions and make sense of scientific ideas
- Using scientific skills, knowledge and understanding to think creatively and critically

- Recognising the impact the sciences make on individual's lives, on the lives of others, and on environment and society.

Learners may apply their understanding of scientific concepts, ideas and principles within and across a range of scientific contexts. Consideration of coverage of scientific issues in all types of media provides learners with opportunities to apply skills in analysing and interpreting evidence, to draw conclusions and to consider the impact of science on individuals, the environment and society. Practitioners will provide opportunities for children and young people to develop an awareness and increasing understanding of the importance of science in society, the economy and the world of work. Through their learning in the sciences, learners will develop important transferable skills for learning, life and work. These skills include being able to: analyse and evaluate their own work and the work of others; solve problems of increasing complexity; collaborate effectively; think and act creatively; develop and use their digital competencies.

Using the Benchmarks for Assessment

The Benchmarks support teachers' professional judgement of achievement of a level. They set out very clear statements about what children need to know and be able to do to achieve each level of the curriculum. They streamline and embed a wide range of existing assessment guidance (significant aspects of learning and progression frameworks) into one key resource to support teachers' professional judgement.

Assessment judgements should be made using the Benchmarks for each curriculum level. The Benchmarks describe the standards that children and young people need to meet to achieve a level. The Benchmarks are grouped together to support holistic assessment and avoid assessment of individual Experiences and Outcomes.

Assessment is an on-going process to support learning. The Benchmarks should be used to help monitor progress towards achievement of a level and to support overall professional judgement of when a learner has achieved a curriculum level. They support professional dialogue, moderation and monitoring of progress in learning.

Evidence of progress and achievement will come from:

- Observing day-to-day learning within, and outwith, the classroom.
- Coursework, including tests.
- Learning conversations.
- Planned periodic holistic assessments.
- Information from standardised assessments.