curriculum for excellence:
sciences
principles and practice

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Principles and practice

Science is an important part of our heritage and we use its applications every day in our lives at work, at leisure and in the home. Science and the application of science are central to our economic future and to our health and wellbeing as individuals and as a society. Scotland has a long tradition of scientific discovery, of innovation in the application of scientific discovery, and of the application of science in the protection and enhancement of the natural and built environment. Children and young people are fascinated by new discoveries and technologies and become increasingly aware of, and passionate about, the impact of science on their own health and wellbeing, the health of society and the health of the environment.

Through learning in the sciences, children and young people develop their interest in, and understanding of, the living, material and physical world. They engage in a wide range of collaborative investigative tasks, which allows them to develop important skills to become creative, inventive and enterprising adults in a world where the skills and knowledge of the sciences are needed across all sectors of the economy.

What are the main purposes of learning in the sciences?

Children and young people participating in the experiences and outcomes in the sciences will:

- develop a curiosity and understanding of their environment and their place in the living, material and physical world
- demonstrate a secure knowledge and understanding of the big ideas and concepts of the sciences
- develop skills for learning, life and work
- develop skills of scientific inquiry and investigation using practical techniques
- develop skills in the accurate use of scientific language, formulae and equations
- recognise the role of creativity and inventiveness in the development of the sciences
- apply safety measures and take necessary actions to control risk and hazards
- recognise the impact the sciences make on their lives, the lives of others, the environment and on society
- develop an understanding of the Earth's resources and the need for responsible use of them
- express opinions and make decisions on social, moral, ethical, economic and environmental issues based upon sound understanding
- develop as scientifically literate citizens with a lifelong interest in the sciences
- establish the foundation for more advanced learning and, for some, future careers in the sciences and the technologies.

What is the thinking behind the structure of the framework?

The sciences curriculum area within *Curriculum for Excellence* has to meet some significant challenges. While every child and young person needs to develop a secure understanding of important scientific concepts, their experience of the sciences in school must develop a lifelong interest in science and its applications.

Content has been updated and account has been taken of research evidence on learning in science and of international comparisons. As a result, there is a strong emphasis on the development of understanding and on critical evaluation, and expectations in some areas have been raised.

The key concepts have been clearly identified using five organisers:

- Planet Earth
- Forces, electricity and waves
- Biological systems
- Materials
- Topical science.

Further explanation of the rationale for each organiser is provided within the framework. Through these organisers, the framework provides a range of different contexts for learning which draw on important aspects of everyday life and work.

The experiences and outcomes tap into children's and young people's natural curiosity and their desire to create and work in practical ways. They can act as a motivation for progressively developing skills, knowledge, understanding and attitudes, and so maximise achievement.

The level of achievement at the fourth level has been designed to approximate to that associated with SCQF level 4. As in other curriculum areas, the fourth level experiences and outcomes provide possibilities for choice: it is not intended that any individual young person's programme of learning would include all of the fourth level outcomes.

Schools and teachers will plan to offer different combinations of the experiences and outcomes to provide programmes that meet the needs of children and young people and provide a sound basis for more advanced study within the discrete sciences.

What learning and teaching approaches are useful in the sciences?

Although the content of the curriculum is important, the high aspirations of the sciences curriculum within *Curriculum for Excellence* will only be achieved through high quality learning and teaching. The sciences experiences and outcomes are designed to stimulate the interest and motivation of children and young people and to support staff in planning challenging, engaging and enjoyable learning and teaching activities. They allow flexibility and choice for both teachers and learners to meet individual learning needs.

Effective learning and teaching approaches extend experiential learning from the early years into primary school and beyond. As children and young people progress in their learning of the sciences, teachers can take advantage of opportunities for study in the local, natural and built environments, as an opportunity to deepen their knowledge and understanding of the big ideas of the sciences. Teaching and learning approaches should promote thinking as well as provide opportunities to consolidate and apply learning.

In the sciences, effective learning and teaching depends upon the skilful use of varied approaches, including:

- active learning and planned, purposeful play
- development of problem solving skills and analytical thinking skills
- development of scientific practical investigation and inquiry
- use of relevant contexts, familiar to young people's experiences
- appropriate and effective use of technology, real materials and living things
- building on the principles of Assessment is for Learning
- collaborative learning and independent thinking
- emphasis on children explaining their understanding of concepts, informed discussion and communication.

Through involvement in a wide range of open-ended experiences, challenges and investigations, including those related to the applications of science in areas such as engineering, medicine and forensics, children and young people develop skills of critical thinking and appreciate the key role of the scientific process both in generating new knowledge and in applying this to addressing the needs of society.

What skills are developed in 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. The experiences and outcomes support the development of the attributes and capabilities of the four capacities of *Curriculum for Excellence* by encouraging teachers to consider the purposes of learning and to plan for active learning.

The skills detailed below draw on research from other countries and on the signposts to the four capacities detailed in the HMIE 2008 publication *Science – A portrait of current practice in Scottish schools*.

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.

How can I plan for progression in the skills of scientific investigations, inquiry and analytical thinking?

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.

A broad indication of expectations for the development of these skills at second level and at third/fourth level may be helpful.

Second level

Children take part in a range of scientific investigations and inquiries which develop their understanding of the underlying scientific concepts appropriate for second level. They develop a growing awareness of themselves and the world around them through observation, collecting specimens and carrying out experiments. They develop their ability to formulate questions or predictions based on observations or information that can be answered through experimentation, inquiry and research. As they answer these questions, they show an increasing awareness of the factors that could be changed and can plan a 'fair test' that involves keeping all the factors the same except one.

While conducting experiments, children are able to safely use simple tools, equipment, apparatus and procedures. They make observations, collect information and make measurements accurately using relevant devices and standard units and ICT where appropriate. They can select, with assistance, appropriate methods to record their findings.

Learners at this level use simple charts and diagrams to present, analyse and interpret their findings, identifying simple relationships, making links to their original questions or predictions and drawing conclusions consistent with findings. They can present their findings in writing, orally or visually using a variety of media.

Third and fourth level

Young people take part in a range of scientific investigations and inquiries which develop their understanding of the underlying scientific concepts appropriate for third and fourth levels. They will take a more quantitative and formalised approach to investigations and inquiries. As learners plan and design their investigations, they identify a number of key questions, formulating hypotheses and predictions based on observation or their knowledge. They control and vary an increased number of more complex variables.

Learners become more evaluative and increasingly take the initiative in decision making about samples, measurements, equipment and procedures to use. They demonstrate increased precision in their use of terminology, units and scales. They apply safety measures and take the necessary action to control risk and hazards. They collect and analyse increasingly complex data and information including using data loggers and software analysis tools.

Young people establish links between their findings and the original question, hypothesis or prediction. They establish relationships between variables and use a relationship, equation or formulae to find a qualitative or quantitative solution. They evaluate a range of aspects of their investigation or inquiry including the relevance and reliability of the evidence.

Young people provide explanations of their findings based on evidence in terms of cause and effect and by applying their understanding of the underlying scientific concepts. They begin to consider alternative explanations and apply or extend conclusions to new situations or identify further studies. They communicate effectively in a range of ways including orally and through scientific report writing.

How does the science curriculum support development of the 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.

What are broad features of assessment in sciences?

Assessment in the sciences will focus on children and young people's knowledge and understanding of key scientific concepts in the living, material and physical world, inquiry and investigative skills, scientific analytical and thinking skills, scientific literacy and general attributes. Teachers can gather evidence of progress as part of day-to-day learning, and specific assessment tasks will also be important in assessing progress at key points of learning.

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?

Progression in knowledge and understanding can be demonstrated, for example, through children and young people:

- providing more detailed descriptions and explanations of increasingly complex scientific contexts and concepts
- using a wider range of scientific language, formulae and equations
- presenting, analysing and interpreting more complex evidence to draw conclusions and make sense of scientific ideas.

They 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.

How can I make connections within and beyond the sciences?

The sciences experiences and outcomes encourage links between the sciences and with other curriculum areas in order to foster deeper, more enjoyable and active learning. Experiences and outcomes relating to Earth science are located in both the social studies and the sciences frameworks and therefore offer an excellent vehicle for interdisciplinary working. Links exist between, and across, the sciences and other areas of the curriculum: for example, engineering offers possible links among the sciences, mathematics and the technologies. Such practice provides children and young people with opportunities to recognise the connectivity which exists across curriculum areas as a means of understanding the world around them.

All science teachers will look for opportunities both to develop and reinforce science knowledge and skills within their teaching activities and to work with their colleagues in other areas to plan interdisciplinary studies and a coherent approach to the development of literacy and numeracy skills, aspects of health and wellbeing and ICT.

Through self-evaluation, schools and departments will plan for an appropriate balance of learning and teaching approaches, progression in skills, and effective use of interdisciplinary work to deepen and extend learning.