Developing an approach to teaching and learning in Science

A high-quality science education provides the foundations for understanding the world through the specific disciplines of biology, chemistry and physics. Science has changed our lives and is vital to the world's future prosperity, and all pupils should be taught essential aspects of the knowledge, methods, processes and uses of science. Through building up a body of key foundational knowledge and concepts, pupils should be encouraged to recognise the power of rational explanation and develop a sense of excitement and curiosity about natural phenomena. They should be encouraged to understand how science can be used to explain what is occurring, predict how things will behave, and analyse causes.

NC 2014

Knowledge and Understanding of the world: *Children know about similarities and differences in relation to places, objects, materials and living things. They talk about the features of their own immediate environment and how environments might vary from one to another. They make observations of animals and plants and explain why some things occur, and talk about changes*. ELG 14

PRINCIPLES APPLYING TO THE AIMS OF SCIENCE EDUCATION - INTENT

(ASE Working with Big Ideas in Science Education)

Throughout the years of compulsory schooling, schools should, through their science education programmes, aim systematically to develop and sustain learners' curiosity about the world, enjoyment of scientific activity and understanding of how natural phenomena can be explained.

Science education should provide every student equally with opportunities that enable them to take an informed part in decisions, and to take appropriate actions that affect their own wellbeing and the wellbeing of others and the environment. It should aim to develop:

- understanding of a set of big ideas in science which include ideas of science and ideas about science and its applications
- scientific capabilities concerned with gathering and using evidence
- scientific attitudes and dispositions.

Teaching and learning at Wormley Church of England Primary School aims to encourage children to wonder, ask questions and follow their own lines of scientific enquiry, sparked by curiosity through hands-on practical investigation and observation.

- Inspiring pupils' sense of excitement and curiosity about natural phenomena and active enquiry
- Equipping pupils to understand how science can be used to explain what is occurring, predict how things will behave and analyse causes
- Developing a love of Science and investigation

We encourage children to notice carefully and deeply, and demonstrate their learning in a variety of ways: reports, models, drawings, keys, presentations, scientific write ups, cartoons, stories etc. Learning can be recorded in the children's science books, writing books, a class folder, reflection logs etc. At least one piece of quality writing from the science topic should be recorded in the children's writing books.

SCIENTIFIC ENQUIRY

There are five types of enquiry in working scientifically and questions may need a different type of enquiry to be answered:

Fair testing- changing one variable to observe its effect while controlling all of the other variables e.g. which kitchen roll is most absorbent? variable to change: type of kitchen roll variable to measure: how much water it will soak up variables to keep the same: volume of water it is placed in, size of the kitchen roll
Research from secondary sources – this includes books, internet, pictures, visitors and experts
Observing over time – observing and noting change, e.g. observing egg shells deteriorate in different liquids
Identifying and classifying – arranging and sorting objects, materials and livings things into particular sets according to certain characteristics. (These can be characteristics and groups designed by the children or recognised groups such as carnivores, omnivores and herbivores).
Looking for patterns- observing and recording patterns in nature or carrying out a survey where all of the variables cannot be controlled, e.g. where do daisies grow? Do children with the longest arms have the longest legs?

4 KEY CONCEPTS:

SCIENTIFIC PROCESS - Scientists learn and gain knowledge with observations and experiments. The scientific process begins with posing a question, developing a hypothesis and making educated predictions. Experiments, data evaluation, making adjustments and confirming results follow. Scientific results must be observable, measurable and repeatable. Common elements of the scientific process include identifying, measuring and reporting cause and effect. The scientific process is important because it eliminates personal biases and can change what others decide to believe
ORGANISATION AND SYSTEMS - Organising objects and phenomena into a logical order helps individuals understand a subject's complexity or place in a list of hierarchies. For example, plants and animals are organised by kingdom, phylum, class, order, family, genus and species. Scientists also organise various components into systems. A solar system, for instance, contains a sun, planets, moons, dwarf planets and comets.
VARIATION, CHANGE AND DIVERSITY - Variation observed in elements helps individuals understand the distinctive properties found in objects. By understanding these differences or how elements change, individuals can better predict the outcome of modifications. For example, exposing water to heat or freezing temperatures, which can cause it to freeze and expand, evaporate or boil. Understanding diversity in the natural world gives better insight into how ecosystems work and depend on different elements to carry out their intended functions. For example, water in an ecosystem provides a natural habitat for aquatic animals, acts as a source of hydration for others and provides nutrients to plants. Warm water in springs can serve as a warm refuge for animals that live in cold places. In its frozen form, water is a habitat for animals like polar bears or those that use the snow as camouflage from predators.
SCALE - The use of scale quantifies measurable items. Each type of scale has its own respective units of measurement. Thermometers, for example, measure temperatures using the Fahrenheit, Celsius or Kelvin scales. Rulers indicate the size of an object using the metric scale. Scientists use relative scale to help others understand a concept related to size and maintain the proportions in question. An example of relative scale is an astronomer using a large beach ball to represent the sun and several balls of various sizes for planets. By placing the smaller balls around the beach ball, the scientist demonstrates the size of the planets in relation to the sun and indicates their positions in the solar system.

DEVELOPING THE SKILLS OF A SCIENTIST

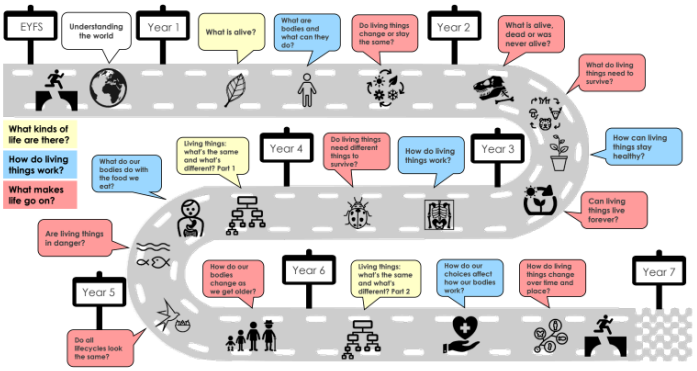
The skills of a scientist are made clear to the children to support them in behaving like a Scientist

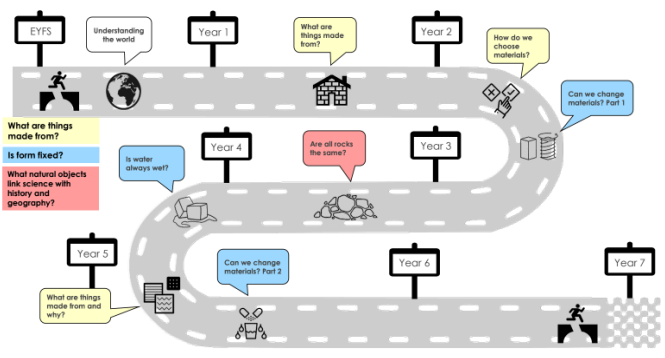
Questioning	Manipulating variables	Making links
Predicting	Problem solving	Deducting
Planning	Observing	Concluding
Fair testing	Measuring	Communicating

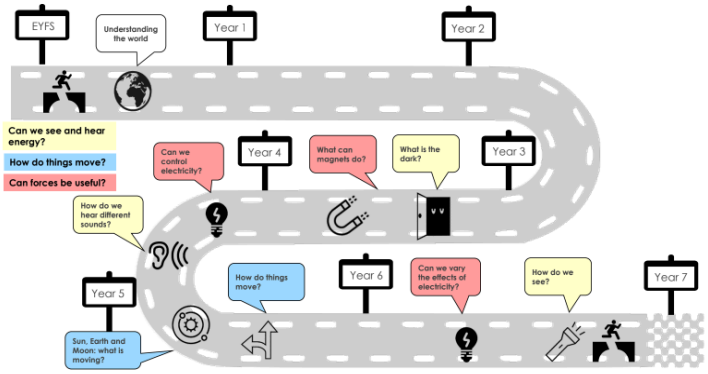
PROGRESSION IN KNOWLEDGE AND SKILLS

Progression in knowledge has been mapped out in detail across the 3 areas: Biology, Chemistry and Physics
https://drive.google.com/drive/u/0/folders/1mbcgg1TJ5NQfg0zTCTB63UC_FcPZ2LD9

The road maps below helps us think through progression in knowledge







Progression of skills can be found in the Working Scientifically Progression Grids
https://drive.google.com/drive/folders/1i5qDFCvutYF3aLLiCXyQoMxc61MX1SPc

SCHEME OF LEARNING - IMPLEMENTATION
A scheme of learning maps out the Science to be taught in each year group and suggests appropriate investigations.
https://drive.google.com/drive/folders/1fwU2K04___0h09hL-6zOrfVI5diALdX9

VOCABULARY
The ASE planning matrices identify the key vocabulary for each science topic
https://drive.google.com/drive/u/0/folders/1gn95ua0RUB-kOoRPszT1bXmUeRJ6UYth

MEASUREMENT
Non-standard measurements
Pupils in KS1 do not necessarily need to use standard units (cm, ml) to measure and record differences and changes. Pupils can use non-standard measurements e.g.

- Height - strips of paper, height in leaves, height in pens
- Amount of water - photos, strips of paper, a pen to mark on how it changes over time

Accurate and precision measurement
Pupils in KS2 need to make accurate and precise measurement. To make an *accurate* measurement pupils need to use equipment properly to take careful measurements without error. To make a *precise* measurement pupils need to use measuring equipment with a smaller interval e.g. rulers and mm, temperature probes that measure to 0.1 and scales which measure to 1g etc.

MASTERY
In Science, it is important for children to be given opportunities to demonstrate how they can apply skills and concepts from previous learning and other curriculum areas. Open ended questions such as 'Why do footballers in an evening match often have four shadows?' and discussion questions such as the Concept Cartoons allow children to demonstrate their thinking and understanding through equipment, diagrams and text. This way children can explain and justify their reasoning. When children are able to do this, we might consider that they are mastering the curriculum.

ASSESSMENT
In order to support children in their ability to 'know more and remember more' there are regular opportunities to review the learning taken place in previous topics as well as previous lessons.

- There are working walls in each classroom displaying key vocabulary and information to support the children with their acquisition of knowledge and these are used for pupils to refer to. Use of science wheels in books and on displays identifies and records science skills demonstrated by the children.
- Effective use of education visits and visitors are planned, to enrich and enhance the pupil's learning experiences within the Science curriculum.
- Teachers use assessment for learning in each lesson to identify and address misconceptions.
- EY and KS use floor books to record science learning. Each year group records examples of practical science learning in their reflective logs.
- Cross-curricular links are made during the planning process and within lessons, with other subjects such as Maths, English, computing and P.S.H.E.
- Hexagons are used pre and post assessment to inform understanding, prior knowledge and teach key vocabulary. End of unit assessment questions/quizzes are used to inform formative assessment on Arbor.

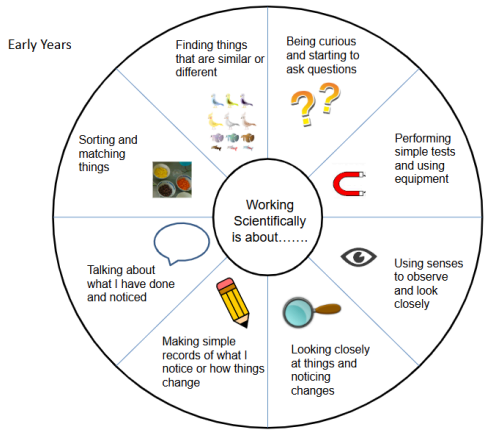
The ASE exemplification materials supports teacher assessment.
https://drive.google.com/drive/u/0/folders/1gn95ua0RUB-kOoRPszT1bXmUeRJ6UYth
Attainment and progress is tracked on Arbor.

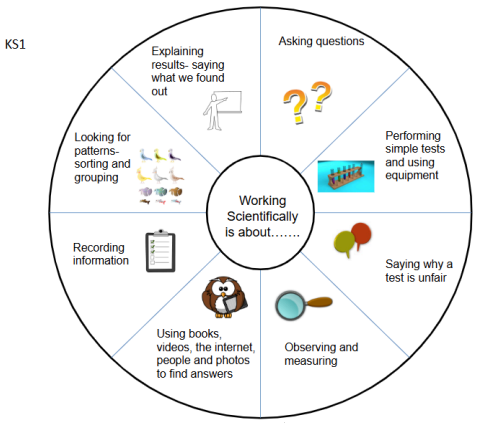
NATIONAL SCIENCE WEEK

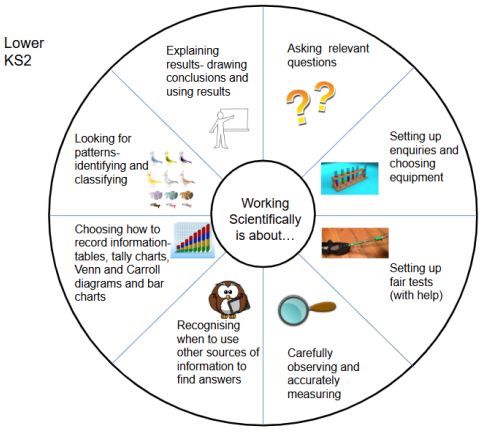
National Science Week is celebrated each year with a Wormley Science Week. Each year we choose a different focus for learning. This is an opportunity for visits, visitors and investigations with the whole week dedicated to Science learning.

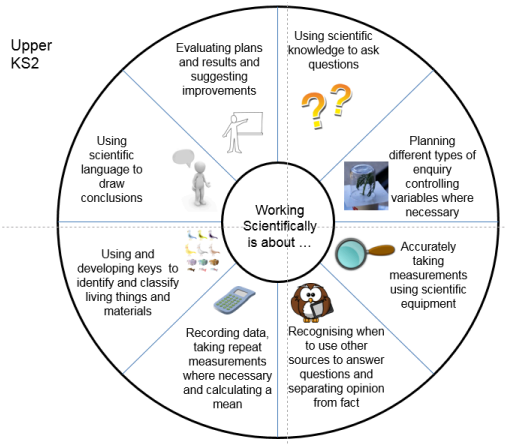
WORKING SCIENTIFICALLY WHEEL

The wheel should be kept in children's books and on a science working wall in all classrooms.









IMPACT

The impact of our curriculum design will lead to excellent progress over time, across key stages, taking into consideration each child's starting point and learning journey. Through various investigations, enrichment opportunities, and interactions with experts, our science curriculum will lead pupils to be enthusiastic science learners and understand the impact that science has on their day-to-day lives, and the implications it has for their futures. Pupil Voice will show progression of content knowledge, with appropriate vocabulary which supports and extends understanding. Children will be confident in discussing science using ambitious scientific vocabulary. Displays around school and books will show that there is a varied and engaging curriculum which develops a range of scientific understanding and knowledge.

FOREST SCHOOL EDUCATION

We have chosen to create a Forest School area and train two Forest School leaders because we believe in the philosophy and aims of Forest School education. Our intention is to enable each child attending Forest School sessions to have the opportunity to develop an inquisitive and positive relationship with the natural world; to increase confidence, self-esteem and respect in preparation for an ever changing world; and for every child to have the opportunity to achieve their holistic, full potential. (See FS leaflet)
This is very relevant to our children as many live in flats and do not have so much opportunity to play and learn outside.

Following are some exemplars for scientific enquiry (many more are in the drive)

Exemplar 1 **Which is the best towel for a hairdresser?**

BOX 1 Skills

Fair test: Comparing what makes a difference, e.g. Which 'towel' material will absorb the most water? Used when we can control all the variables except the one we are changing.

Exploring: e.g. What happens when you add water to fabrics?

Observing over time: e.g. How long does it take to rot? (often linked to exploring).

Pattern seeking: e.g. Do thick fabrics absorb more water than thin fabrics? Used when there are many variables that we cannot control and so we cannot do a true fair test.

Problem solving: Using the science we know to solve a problem, e.g. Using what you know about materials, design a fabric that would make a good towel – which thread would you use, how might you weave it?

Sorting and classifying: Putting things into groups based on their characteristics/properties, e.g. In how many ways can you sort these materials?

BOX 2 Enquiry

Using a pattern-seeking style of question, such as: 'How does the thickness of the towel affect the amount of water it absorbs?' we can focus on explaining the results, in a conclusion, ensuring that it is consistent with the evidence presented, i.e.:

Can the children explain the strength/limitations of the evidence that supports their decisions/ judgements/conclusion?

Have they provided a scientific basis for what they have found out? You might provide some prompts for the children to scaffold their work:

Conclusion: Look for a pattern – Look at your table of results or graph. – Describe any patterns you can see. – Are there any results that do not fit the pattern?

Make a concluding statement – Answer the question you are investigating. – Was your prediction correct?

Explain your conclusion – Find some science that explains your concluding statement. – Is there another investigation you would need to do?

Initial discussions focus on what a towel is for and what properties it needs to have. There could be links to mathematics in terms of cost of the towels, number of towels used per customer, how long a towel might last and how these factors may affect the hairdresser's decision. But what type of enquiry would it be? It depends on the question that is asked or they ask and work on. Once you have decided on the type of enquiry, you need to consider which skill you want to work on and develop with the children. Some enquiry types lend themselves better than others to certain skills. You can and should have a single one that you want to focus on with the children in order to develop success criteria with them.

Exemplar 2 **I'm forever blowing bubbles. And I want mine to be the biggest and the best.**

How can I do this?

Sometimes the 'best' way to start an enquiry activity is with a 'best challenge', such as developing 'the best' bubble mixture using unknown quantities of washing-up liquid, water and glycerine. This is a great way to get children engaged and motivated and they can start to notice patterns and relationships between variables. Ideally, it lends itself to small-group, open-ended investigation.

Children will first need to discuss their definition of 'best bubble' (life span, quantity, size, etc.) and then plan, carry out and record in their own chosen way. However, although by considering the variables you might think this is a fair-test investigation, it isn't – you can't control the blowing of the bubble unless you have a mechanical device. It is more of a pattern-seeking enquiry; noticing patterns and relationships is a good skill to develop with this enquiry.

Open-ended investigations, such as challenges like 'the best', are a fantastic way for teachers to focus on teaching other specific skills of enquiry, such as children setting up their own tests, choosing and using equipment and making observations and measurements. They don't have a specific 'answer' so they enable children to work as 'real scientists'. You will be amazed by the squeals of delight coming from everyone as they blow their bubbles: you are never too old to blow bubbles – yes even teachers!

This activity can be adapted to suit the full primary age and ability range, so could be a whole school investigation, perhaps as a science day or part of a science week, especially as it isn't what you would normally teach as part of subject knowledge.

Exploring: e.g. What happens when you mix different quantities?

Observing over time: e.g. How big is the bubble? How long does it last? (often linked to exploring).

Pattern seeking: e.g. Which combination of mixtures is most effective? Used when there are many variables that we cannot control and so we cannot do a true fair test.

Problem solving: Using the science we know to solve a problem, e.g. Using what you know about the elements to design a bubble mixture to make large bubbles.

Exemplar 3 **A cup of tea fit for the Queen**

Many people drink tea but what investigations can be done with a tea bag or with loose-leaf tea?

Children can consider the different teabag designs – round, rectangular, pyramid. Which shape enables the tea to diffuse within the water most efficiently? Once they decide what they want to investigate they need to design an investigation. How will they know if the tea id diffusing efficiently?

Investigations with tea

Classification: The tea bag style, the holes, the colour or size of the tea leaf, etc.

Pattern seeking: Do any of the above factors affect the colour of the tea? Does the time the tea bag is left in the water or the temperature of the water affect the colour of the tea?

Researching: Where does tea comes from?

Observing over time: How long does tea keep warm in a teacher's playground mug?

Modelling (older children): How does a tea bag work? Design and make: A machine to dunk a tea bag for the right amount of time for the perfect cup of tea.

Surveying: Milk in first or last – what do people think?