Talk for Writing

How Talk for Writing supports Science

For schools already using the Talk for Writing (TfW) approach in English, integrating the key elements of TfW into how you teach science, alongside all the other subjects, gives the children and the teachers one unifying, powerful approach to learning across the curriculum.

This resource and all accompanying videos can be found at:
http://www.talk4writing.com/science

Introduction

Julia Strong and Pie Corbett

The TfW approach, once embedded into how children learn English, can support learning across the curriculum enriching whichever schemes and resources schools choose to support other subjects.

How Talk for Writing Supports Science is very much still work in progress. Therefore we are providing free online resources for schools within the TfW network so that together we can build a more powerful understanding of how TfW supports science. Please use these resources and feedback your findings to Julia Strong (Julia.strong@talk4writing.com).

This project is based on the work of TfW training schools. Particular thanks go to Tamara Fletcher, science lead at Warren Road Primary School, Orpington, and Nasrin Ahmed, science lead at Yew Tree Community School, Birmingham (supported by Michael Raynor) who have generously contributed to the development of TfW in science over the years. These schools are flagged up by their logos, as pictured here. **Pages 45 and 46** explain why both schools use TfW to support science.

The TfW approach is not a blueprint to be followed precisely but rather an underpinning process that can be adapted to suit the needs of the subject and the children. Science not only has underpinning content and processes that need to be retained and put into practice but it also needs to be expressed clearly and precisely. Selecting the right word in English relies on the effect you want to achieve as a writer; in science, it is much more a question of using the right words to convey processes and findings accurately. The focus of this resource, therefore, is on opening children's minds to the delights of scientific enquiry through taking part in fun, focused activities that help them talk their way to scientific understanding. Their learning will be meaningful because they will have worked like scientists – understanding what they were doing, why they were doing it and explaining what they have done scientifically. When necessary, they will be able to write it down.

Science in primary schools is all about helping children to understand the nature, processes and methods of scientific enquiry. This enables them to work scientifically. This short video from the Primary STEM (Science, Technology, Engineering and Maths) Consultancy explains clearly and simply what working scientifically means and usefully compares the underpinning science skills to how spelling, punctuation and grammar are the skills that underpin writing: https://www.youtube.com/watch?v=nvIltte6kDc.

Video clip 1 shows two pupils from Warren Road Primary School explaining the primary science curriculum. *Working scientifically* means children learn specific skills which enable them to answer questions about the world around them.

What pupils are enquiring into may relate to biology, physics or chemistry but the following five methods of enquiry remain the same:

- observing over time;
- pattern seeking;
- classifying and grouping;
- comparative and fair testing;
- research using secondary source.

Science is all about asking questions and knowing how to answer them – will the question best be answered by a pattern-seeking enquiry or would a comparative-test investigation be better? How can I be certain my findings are accurate? TfW enables children to develop the skills of working scientifically through a successful strategy that they are already very familiar with. It helps them talk their way to understanding the skills that underpin scientific enquiry. TfW strategies help children understand, retain and apply scientific knowledge and concepts through helping them co-construct the skills and related toolkits for the 5 types of science enquiry progressively. If you can do the science skills, you can do the enquiries.
Once you have established in EYFS or Year 1 how to conduct a scientific enquiry, this acts as a form of template that you can build on for all future scientific enquiries across the years. In effect, each different investigation is a form of innovation and, over time, you build up the independent skills of scientific enquiry. The children know how to work scientifically. The language they use will become more sophisticated across the years as will the complexity of how to investigate but the underpinning processes remain the same. And, of course, they need secure understanding of key blocks of scientific knowledge and concepts in order to progress to the next stage.

A note on teacher's notes! These resources, including **17 video clips**, have been constructed as teacher's notes to support anyone providing CPD for their school. Watching film in training sessions is more effective if the audience is given a question to consider while watching the clip. Possible questions have been integrated into the text.

To see the process in action, and for information about training, visit . www.talkforwriting.com/training.

Julia Strong and Pie Corbett

Chapter 1: The Imitation Stage

The **Imitation Stage** is the most important stage since this provides the basis on which understanding and independent application can be built. In this resource it is divided into eight sections but, in practice this is not a fixed order. Teaching is an art. The order in which the aspects are introduced will change and, in many cases, they will be interwoven, depending on what is being taught and the progress the class is making. For example, talking your way to understanding is a thread that will run through every aspect of the unit. But, for obvious reasons, the hook to engage the children and the ***cold task*** to establish what they already know will form the starting points for all units.

1. The hook and the cold task

Motivating children to be curious and ask questions about our world is a key aspect of an enquiry-based subject like science. In the words of Professor Brian Cox:

> ***"It's that process of interest in nature because you are fascinated by it which has generated the knowledge on which our civilisation rests."***
> BBC Breakfast, 8th April 2021

The more we can find links that children can relate to, the more likely they are to engage with learning and become fascinated by the world around them. Hence the importance of finding good hooks to engage children with their learning in science.

The school environment should encourage children to start asking questions about the world around them. The corridors of Montgomery Primary Academy, a TfW training school in Birmingham, are an Aladdin's cave of hooks to engage children with reading and learning. Every now and again, you come across a cupboard labelled *Wonder*. When the children open the doors, they find a treasure trove of items linked to scientific enquiries or topics, or even the wealth of occupations that science can lead to, as illustrated below:

At the beginning of each science unit, teachers plan a **hook**. This often acts not only as an exciting introduction to the unit of work to engage the pupils' interest, but also provides a means by which the teacher can gather initial assessment of how much the pupils know about the focus of the unit.

For example, at Yew Tree, at the start of Year 3's *Light and Darkness* unit, the children walk into a darkened room with window and door blinds drawn to introduce the concept of darkness being the absence of light. The teacher asks the simple question: ***"Why can't we see?"*** This provides an engaging opportunity to gather how much understanding the pupils already have.

Hooks can take the form of a picture, video or scenario: anything to jog the children's memory of the last time they studied the concept and engage them with the new enquiry. At the start of the Year 4 *States of Matter* unit at Yew Tree, pupils are presented with everyday items to classify into *Solids*, *Liquids* and *Gas*, see **video clips 2a and 2b**. The teacher acts as facilitator to ensure the emphasis is on pupil discussion and reasoning as this transcript illustrates:

Transcript Video clip 2b

A child: *Looking carefully at the sand and... so I think it's solid.*

Teacher: *Do you agree with that, Lisa?*

Lisa: *Maybe.*

Teacher: *Why is that 'maybe'?*

Lisa: *It's in the solid section so that should be really hard not soft.*

Teacher: OK. *Have a feel. Is it hard?.*

A child: *No.*

Teacher: *So, why have we placed it under solid?*

A child: *Because most of us decided it was solid, so we put it in solid.*

Teacher: *Why have you decided it's a solid?*

A child: *Because it's not… so we put it in solids.*

Teacher: *What do you know about liquids?*

A child: *Liquids are watery.*

Teacher: *So, can the sand move?*

Children: *Yes. But…*

Teacher: *OK.*

Such an activity intrigues the children and informs the teacher of any misconceptions that the children may have. If you use this clip for training, ask this question to focus the audience's attention: ***"Why are small group activities like this useful?"***

At Warren Road, Tamara has similarly found that the ***hook*** and ***cold task*** can often be combined – the one to grab the children's interest; the other to inform the structure and content of the unit given the children's prior knowledge. Moreover, given the nature of a science unit, additional information will be added in throughout the unit which often leads to a series of ***mini hooks/cold tasks*** to assess what they know so far and maintain engagement.

Cold-task hooks are an excellent way of discovering what misconceptions the children may have so, in the Year 2 plant unit at Warren Road these were the common misconceptions to look out for:

- plants are not alive as they cannot be seen to move;
- seeds are not alive;
- all plants start out as seeds;
- seeds and bulbs need sunlight to germinate.

Explorify activities (explorify.uk) can form excellent ***hooks/cold tasks*** to get discussions going and help you discover misconceptions and establish prior knowledge. These activities include engaging *What if*… questions. Children at Warren Road love it.

This ***cold task*** for the Year 2 unit on plants was devised to help pupils know that all plants are different, but have some parts in common. The children were given vocabulary cards with these words: *leaves*, *stem*, *trunk*, *root*, *bulbs*, *flower*, *berries*, *seeds*, *fruits*, *evergreen*, *deciduous* and *germination* and were asked to sort the words into the following categories:

Know	**Heard of but not sure of meaning**	**No idea**

They were then asked to draw a plant and label any of the parts they knew. This was followed by a walk in the school grounds while the teacher explained that the topic was plants and that they were to look at the plants that live in the school grounds. They were asked questions to draw out prior knowledge:

- ***"Can you spot different ones?"***
- ***"What about trees – are they a plant?"***

While sitting under a tree, the children discussed the different parts of the plant – could they see any plants they knew the names of? Then they collected some leaves, roots, flowers and stems. Finally, the children were asked to draw a plant that was different to their first drawing and add any names of plants and labels that they now knew.

Hooks are also regularly introduced throughout units to maintain the children's interest. For, example, in the Year 2 unit on plants the children were asked:

- ***"What if plants could talk?"***
- ***"How could plants talk?"***
- ***"How would different kinds of plants talk to each other?"***
- ***"Why would talking be helpful?"***

Apart from engaging the children, this served to establish another learning intention: plants need water, light, space, air and warmth.

To maintain the children's engagement throughout the unit, growing real plants is essential and served as an ongoing hook. How this contributed to the resulting science toolkit is explained on **page 22**.

This part of the unit was introduced by providing a selection of small plants/plugs and bulbs. The children were initially asked to look at them carefully and prepare to answer these questions:

- ***"What do they have in common?"***
- ***"How are they different?"***
- ***"What is a bulb?"***

Why the cold task matters in science

If comments on *X/Twitter* are anything to judge by, some teachers want to dodge the ***cold task***, seeing it as purposeless or setting up the children to fail. Teachers who understand the power of the TfW approach know that the ***cold task*** is a very useful analytical tool. It is the epitome of formative assessment: assessing what children initially can and cannot do directly informs the focus of the teaching.

This example from Kathryn Kelly, Dame Allan's School, Newcastle, is an 'I rest my case' summing-up proof of how valuable ***cold tasks*** can be. As part of a small TfW online research project team into how useful the approach was across the curriculum, Year 5 teachers at the school were happy to experiment with an extended practical ***cold task/hook*** lasting a whole science lesson because they were familiar with how successful the approach had been in English. They were interested in finding out how easy and how useful it would be if the familiar processes of TfW were applied to science.

Kathryn described the first of a series of lessons on reversible and irreversible changes, leading on from investigating the properties of materials. Previously, investigations had been teacher led but this time she set up a carousel as a form of ***cold task*** to see how much of the work they had understood. The instructions the children were given included the word *observations*. Interestingly, many of the class had no idea what this meant – which Kathryn hadn't expected as they knew the word *observe* and she felt they had used the term *observations* regularly. She commented, ***"So, either we hadn't used it or we had and it had just washed over them."*** Once Kathryn had said, ***"It's what you observe,"*** they understood. In the words of one child: ***"Right then, so I write down what I can see."*** Another child asked, ***"What does 'filter' mean?"***

There's a lot of words to look out for in just one investigation.

The class was challenged to complete a range of tasks relating to separating materials. Kathryn was surprised how difficult some of the children found setting up a relatively simple investigation when left to their own devices. She commented that there were lots of things that she had expected them to be able to do that they couldn't. For example, one task, pictured here, was to separate a mixture of ingredients, including LEGO, marbles, oat-flakes, metal paper clips, sand, salt and rice into their separate groups.

The instruction began with the words, ***"Using the tools you have to hand..."*** The children were provided with large and small sieves and a magnet. Three of the five groups just picked the big bits out by hand and none picked up the large sieve. A lot of children didn't know what it was and those who knew that it was used to separate things, didn't know that it was called a sieve.

There were two magnets, but the children were picking the paper clips out with their fingers. One child, having extracted the paper clips by hand, then noticed that they got attracted to the magnets and wafted the paper clips around on the magnets saying, ***"Look! Look! The magnets have stuck on."*** Later, one child wrote: ***"It will be more difficult to separate the sugar because the sieve is smaller so it will take longer."***

Kathryn commented:

> ***"It was really interesting to find out what they didn't know. By doing it this way, we've eliminated what they did know and established what they didn't know how to use, so now we can focus on the science. It showed that, normally, we started off making a series of assumptions about what the children knew and could do that were ill-founded. When you talk the children through the process, you probably assume they understand lots of things that they don't. I now plan to conduct the investigations one at a time, practise the vocabulary and improve the quality of the explanations."***
>
> Kathryn Kelly, Dame Allan's School, Newcastle

Warren Road has similarly found ***cold tasks*** to be essential to enable you to pitch the unit appropriately whether for the whole class, a group of children or an individual. Tamara illustrated this with the grand tale of what had happened when a Year 4 class's ***cold task*** for a unit on the human digestion system was to eat a grape and draw its journey through the body. The results were very varied with some children delighting in a simple diagram culminating in a lot of poo. But one boy accurately drew the image of the human digestive system – fully labelled with the appropriate technical vocabulary relating to *acid*, *enzymes*, etc. and sat there, somewhat smugly, in teacher-defying mode.

The teacher had to think about what to do. The boy still took part in the fun activities of the unit but his main activity was much more advanced: ***"Do all animals digest food in the same way?"*** And, of course, they don't. So, he investigated that and looked at a variety of creatures including flies and chickens – the latter have gizzards to aid digestion. He became fascinated by this so, when the rest of the class made a 3D model of the human digestive system, he made a model of a chicken's digestive system.

2. Introducing key vocabulary

Vocabulary matters. It is central to our understanding, communication and engagement. Developing the children's understanding of the underpinning vocabulary of science is fundamental to effective science teaching. Building understanding of vocabulary is, therefore, the most detailed section of this resource and it also supported by **Appendix 4 (page 47)** showing the **science vocabulary progression** used by Briar Hill, another TfW training school.

Words are fascinating but tricky things. Many have wide shades of meaning depending on the context in which they are used. You only have to glance at these quotes from the days of the primary science SATs (pictured below) to see that children often mistake the meaning of words. While we may find some of these responses amusing, the source of the error is liable to have been not the children but how the children have been taught. Just consider the glorious sentence: ***"Three kinds of blood vessels are arteries, veins and caterpillars."*** It is easy to deduce that the teacher was talking about *capillaries*, but the child heard the word as something they knew about, *caterpillars*, and nothing ever happened to enlighten them. If we could look in the books of the children who made these errors, we would probably find the key words written down with appropriate definitions carefully copied or stuck into the books. Somewhere along the line, the words have failed to impinge on the children's vocabulary. Getting pupils to write down the definitions of words is a very common method used. The trouble is that, on its own, it will make little difference, apart from keeping everyone quiet. You can copy definitions down without thinking at all about what you are writing. Interestingly, if you have to devise an image to represent the word, you have to think about its meaning. If you add actions to the images, that is even more effective which is one of the reasons the TfW approach is so powerful.

The trouble with words

Quotes from 11-year-olds' science SATS

"Germinate: to become a German."

"H_2O is hot water and CO_2 is cold water."

"Three kinds of blood vessels are arteries, veins and caterpillars."

"When you breathe, you inspire. When you do not breathe, you expire."

"Water is composed of two gins, oxygin and hydrogin. Oxygin is pure gin and hydrogin is gin and water."

"Dew is formed on leaves when the sun shines down on them and makes them perspire."

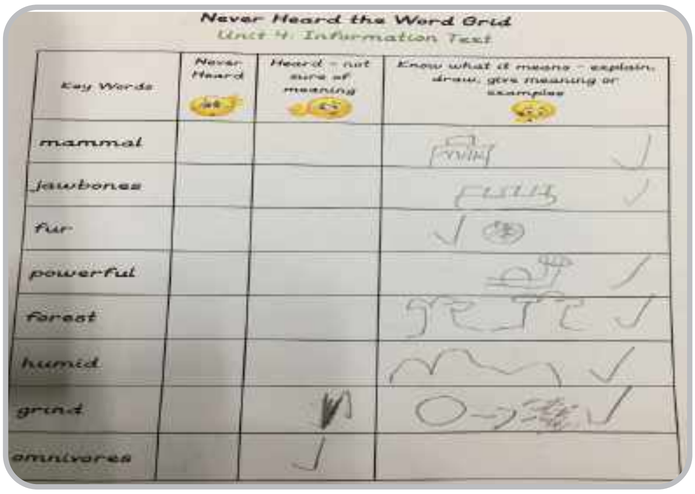
One TfW approach that has proved very powerful right across the curriculum is to introduce the words that will be key to understanding a unit at the very beginning of a unit with a **never-heard-the-word (NHTW)** grid like the one below for a science investigation in Year 4. These can also be used as ***cold tasks*** to establish which words to focus on most to develop the children's understanding.

Never-heard-the-word grid for a Year 4 science investigation

Key words for science investigations	Never heard	Heard – not sure of meaning	Know what it means – jot down meaning/image/symbol
1. hypothesis			
2. variable			
3. compare			
4. fair test			
5. dependent variable			
6. independent variable			

The idea is to give every child a copy of the grid and make it clear that it is not a test – just a way of establishing which words they know and which they are not so familiar with at the start of a unit. However, point out that you will return to this at the end of the unit and expect everyone to know every word confidently. Say each word and put it into a sentence that provides context but doesn't explain its meaning. Then ask the children to tick the appropriate column ('Never heard' or 'Heard – not sure of meaning') or, if they know what it means, jot down its meaning or draw an image or a symbol to represent it. Ask the children to mark their own work and then take it in so you can spot any misconceptions and establish which words will need teaching most. Don't try to go over the meaning of the words immediately but teach them in context as they arise during the unit. If you start going over the meanings of the whole list, teachers tell me that most children will stop listening round about word three, even if they manage to look as if they are listening! The grid can then be developed across the unit, using some of the methods explained below and on the next page, so the children become confident users of the words.

Here, a *NHTW* grid has been used for a unit on animals. As you can see, the child, who cannot write yet, was able to draw images to represent most of the words. They were unsure of the meaning of *grind*, but their image shows they have understood correctly. Unsurprisingly, the word that baffled them was *omnivores*.



Turning *NHTW* grids into small group sorting activities (like the example below, recreated from children's work at Warren Road) is also useful as it gets the children discussing the words. The more they get to say the words, the more confident they will become in using them. You cannot be sure which individuals know what, but this method has the advantage of quickly enabling you to see the words that are causing the most confusion.

Know	Heard of	No idea
Shadow	Artificial	Opaque
Reflect	Observations	Translucent
Travelling	Transparent	Light source
Dark	Scattered	
Blocked	Light	
Natural		

Know	Heard of	No idea
Shadow	Artificial	Opaque
Scattered	Light source	Translucent
Reflect	Observations	
Natural		
Dark		
Travelling		
Light		
Pattern		
Transparent		
Blocked		

Alison Tunney tried this out after online training in 2023:

> ***"The tricky part was how I grouped the children as I have a very mixed attainment class who come from such different backgrounds, i.e. some children in the group had heard of some of the words but some hadn't. There was, therefore, a bit of a dispute as to which column they should place it. They really enjoyed it, however, and it got them talking. We then went over the meaning of the words they were going to use in the first lesson. They could then make links."***

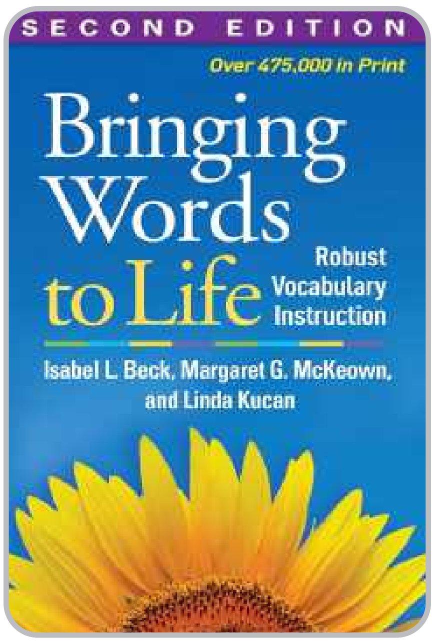
The images below represent the results from three groups.

Know	Heard of	No idea
Healthy	Invertebrates	Pupa
Survive		Larva
Exercise		Vertebrates
Heart		Metamorphosis
Lungs		
Muscles		
Hygiene		

Know	Heard of	No idea
Healthy	Survive	Larva
Exercise	Lungs	Pupa
Heart	Hygiene	Metamorphosis
Muscles	Vertebrates	
	Invertebrates	

Know	Heard of	No idea
Healthy	Lungs	Pupa
Exercise	Survive	Vertebrates
Heart	Larva	Invertebrates
Muscles	Metamorphosis	
Hygiene		

A tried-and-tested method to introduce new key words effectively is the *Isabel Beck routine*. If you are not familiar with Isabel Beck's excellent advice on how to build children's vocabulary, get hold of a copy of *Bringing Words to Life*. Her basic routine is illustrated on the next page.



Firstly, the teacher says the word being focused on – *hypothesis* – and gives a simple, child-friendly definition: *A hypothesis is a good idea that hasn't been fully tested.* This sounds easy but it is not, and significant preparation is required to ensure that your definition doesn't just add further confusion. The teacher then involves the children by saying the word and the definition, and then just saying the definition and asking the children to say the word. After that, the teacher says the word and asks the children to say the definition. Finally, the teacher asks the children to use the word in sentences.

Teaching vocabulary in context
The Isabel Beck routine

1. Say the word aloud: ***hypothesis***.
2. Give a **simple, child-friendly** definition: ***Hypothesis is an idea that hasn't been fully tested.***
3. Involve children in saying the word and the definition.
4. Use the word in sentences.
5. Help children to use the word several times in different contexts.

Imitation
↓
Innovation
↓
Independent application

Given the nature of this particular word, it's important to bring out the fact that this definition is the scientific definition and that, in everyday use, hypothesis is just a fancy word for an idea/suggestion, as in, ***"I've got another hypothesis."*** So, the children could come up with examples of the word in a scientific context and in an everyday context and discuss the difference. They could also talk about how it differs from a 'prediction'. As the image here illustrates, this process takes you from imitation to real independent application. The more the word is used within the unit and embedded in future units, the more the children will gain confidence in using it correctly and understand the word when others use it.

The power of actions in consolidating vocabulary

Teachers familiar with the TfW method of using text maps and actions to help pupils internalise a model text know that actions not only support understanding and retention, but also encourage pupils to enjoy learning the meaning of words. Actions can be used to great effect to warm up the meaning of key words as the image here from a Year 1 classroom in Selby Community Primary illustrates. Displaying such images helps the children retain their understanding.

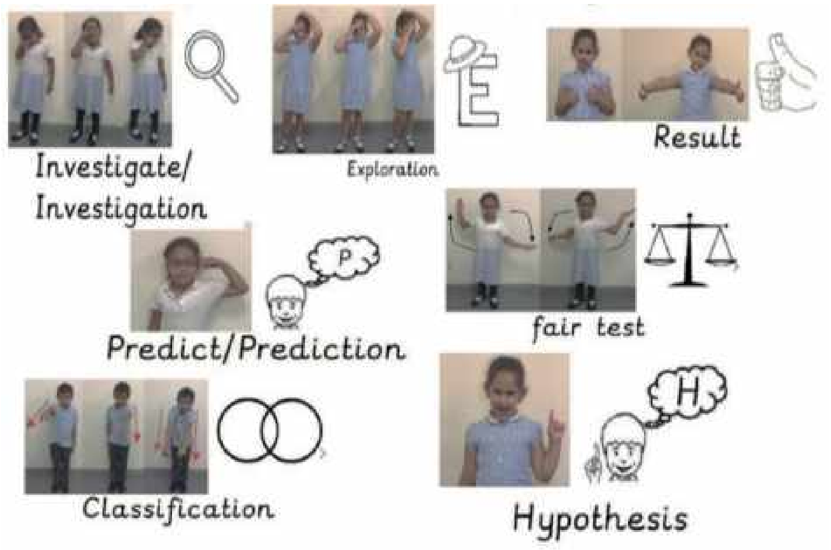
Through a variety of language games linked to actions, the children at Yew Tree quickly come to understand the meaning of the key enquiry types and the action that represents it; they can also give an example of how it is used. Actions are also used to help the children recall the key technical words of each investigation. For example, understanding the difference between *water particles*, *gas particles* and *solid particles* is key to *States of Matter* units across the years so the children are helped to conceptualise the difference through actions, as these images from **video clips 3 and 4** illustrate. A useful question to ask if using these clips for training is: ***"How do the actions help?"***

Actions help the learning be more engaging, meaningful and memorable, as **video clip 5** from Warren Road also illustrates. Here the teacher is encouraging older children to embed some of the key vocabulary of *States of Matter* through saying the words accompanied by the actions that represent their meaning. If using this clip for training, you may want to ask your audience to copy the actions alongside the children, and then see if they can remember the actions without the film when you say the words.

It's also worth looking at **video clip 6** of a group of Year 1 children in a science lesson at Yew Tree to remind ourselves how engaging words can be and how helpful actions are. A useful question to ask here is, ***"How do we know the children understand the meaning of the words?"***

The next stage will be to ensure that the pupils can use these key technical words and any related command terms appropriately as **video clip 7** from Yew Tree illustrates. The Year 1 child in this film is using the word *predict* in a scientific context. He is beginning to embed the language of science enquiry.

The language progression underpinning Yew Tree's approach means that the children are constantly revisiting the tune of science enquiry so they build up all the language patterns they need to express their findings coherently. This enables them to be able to talk like scientists. These games are a quick (5-7 minute) revision of the key enquiry types and are introduced in Reception, as pictured on the next page, using actions.



One of the enquiries is then applied in a game, which the teacher has linked to the main learning in the lesson. This kinaesthetic approach supports the pupils in using the key scientific vocabulary of enquiry, as **video clip 8** illustrates. This imitation of the enquiries at the start of each session allows pupils to understand the structure of science enquiries in a fun, talk-based way. By the end of the **Imitation Stage**, the children have thoroughly internalised the scientific language patterns that they will need to apply their skills to a related enquiry. These science investigation tools are repeated and developed from Year 1-6 and form the underpinning science toolkit **(see page 21)**.

The key language of science is regularly revisited and embedded through text maps **(see pages 25-27)** so that it becomes embedded within the children's working vocabulary. For example, by Year 4, a lesson may start with the teacher asking the children to quickly show the action for a range of enquiry types like *fair test*, *classification*, and *pattern seeking*, and be able to relate these to what they mean in practice, as **video clip 8**, and this image of Nasrin in action, demonstrates.

This kinaesthetic approach supports the pupils in having the confidence to use the key scientific vocabulary of enquiry when talking about what they are doing in science. For example, for a *fair test* there would be a change of variables. Children have actions for variables, which are consistently used from Year 3 to Year 6. This means most children can identify all three variables in a *fair test* by Year 4 at the latest, and all the variables in *pattern seeking* by Year 5 (without confusing it with *fair testing*).

The children need to understand that in this investigation they must only change one variable and consider which variable they are going to measure. The teacher assesses whether the children understand the key concepts of *fair testing*. Following a brief discussion in pairs, ideas are fed back to the class, with the teacher addressing any misconceptions.

More words are added in as the children's understanding of investigations develops so that, by upper KS2, the children are familiar with the technical names of the different types of variables (*the dependent variable*, *the independent variable* and the *controlled variables* that are key to understanding how to conduct science investigations). This enables them to discuss how to investigate whether the location of an ice cube would affect how fast it melts.

This constant revisiting and embedding of understanding, while building up the difficulty of the contexts in which it is applied, pays off. By Year 6, the children are very used to the concepts and talk like scientists as illustrated on **page 30**. And, most importantly, they love science because they understand it and can confidently talk about it. The school has ignited their curiosity and helped them ask meaningful questions.

Tamara from Warren Road summed up why a focus on teaching vocabulary when teaching science is so important:

> ***"The whole principle is about teaching the vocabulary so the children can use that vocabulary to express themselves scientifically. This in turn helps their understanding. You've got to elicit that understanding of vocabulary practically. This is why the TfW approach with its focus on developing vocabulary works so well in science."***

She illustrates this in the Year 2 unit on plants. One of the learning intentions is to ensure the children understand the terms *evergreen* and *deciduous*. So, the teacher made certain there were excellent examples like holly leaves and pine needles that the children could compare with oak, beech or sycamore leaves. The children were asked:

- ***"How are these leaves different?"***
- ***"How are they the same?"***

The children then discussed this including the colour, texture, shape and symmetry of the leaves.

The children were then shown a picture of a sycamore tree and a holly tree in winter and discussed how the sycamore loses its leaves while a holly keeps its leaves – this enabled the teacher to elicit the meaning of the terms *evergreen* and *deciduous* and the children decided on the action to represent each word.

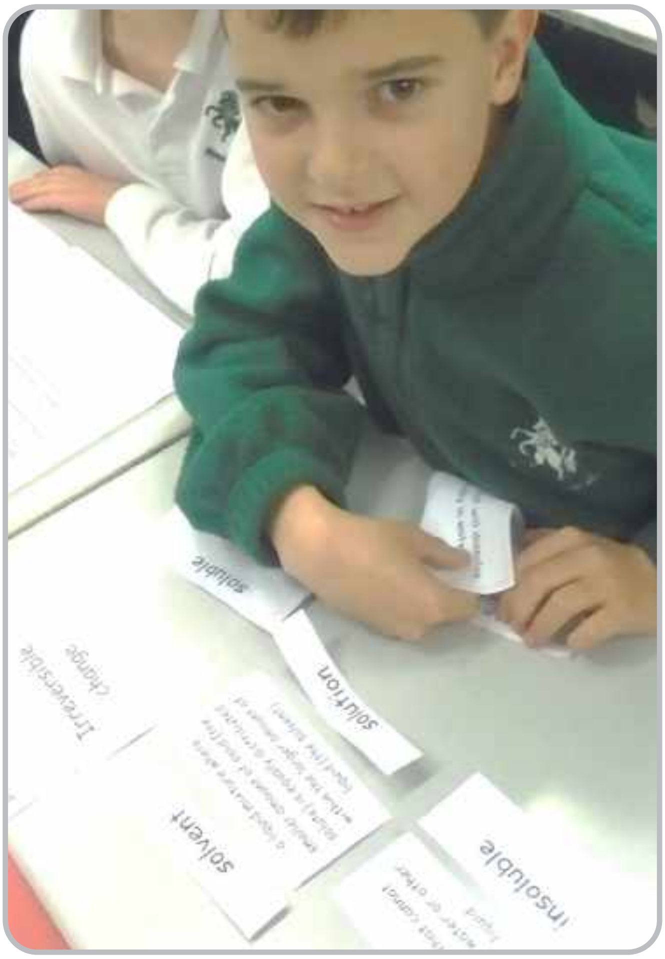
The children were then asked: ***"What are leaves for?"*** And this was discussed.

Another key part of the unit relating to vocabulary was to enable the children to identify the function of the main parts of a plant. They were involved in creating actions for each part of a plant related to its function so that they understood that:

- *leaves* make food using sunlight which creates sugar;
- the *stem* transports water and sugar and supports the plant;
- the *root* anchors the plant in the ground and absorbs water;
- *flowers* enable reproduction by making seeds, berries, fruits and new plants.

Within each unit, key vocabulary like *leaves*, *stem*, *root*, *flower*, *berries*, *seeds*, *fruits*, *evergreen* and *deciduous* is revisited by playing call and response which helps the children internalise the language and deepen understanding of the function of each word.

Small group activities are used to strengthen understanding. Here you can see a sorting activity with a Year 5 group at Warren Road where the children in pairs are sorting key vocabulary and information related to the property of materials.



3. Talking your way to understanding

In written subjects like English, the key vocabulary and recyclable phrasing of whatever type of text is being focused on is warmed up throughout the **Imitation Stage**, so that the children not only understand the words but can also use the key phrasing that underpins the unit. This involves modelling **recyclable generic linking phrases** (e.g. *because*) and **recyclable topic-specific phrasing** (e.g. *In order to solve the problem…*) that are liable to be used again in similar texts or discussions. This enables the children to talk their way to understanding because they can talk the tune of the text.

This acts as a form of thinking/talking frame, which can later be innovated on and applied independently. In such a way, children internalise the language patterns (the tune/disciplinary literacy) of whatever type of text or subject they are focusing on and can use them with confidence.

This process in many ways is even more important in science, since the children have to understand the logic of what they are doing to enable them to work scientifically independently. They have to be able to explain coherently the underpinning concepts and procedures they are using so that, when faced with a science enquiry, they can select which procedure to follow to achieve accurate results.

At Yew Tree, involving the children in talking their way to understanding science scenarios provides the key to helping children understand scientific concepts (**see video clips 8, 9, 11 and 12**). The scenarios are also designed to be engaging. The image here from **video 9** is of a girl explaining her prediction following paired discussion.

In Year 1, because the children are familiar with nursery characters, they are presented with this scenario to discuss: ***Baa, Baa, Black Sheep, Jack and Jill and Humpty Dumpty decided to see who would roll down a hill furthest.***

They are given this hypothesis: **Jack will roll down furthest.** They then have to complete the prediction using this sentence stem: *It is my prediction that… because…*

By Year 3, the scenario may look like this evaporation enquiry: ***Mrs Smith is hanging out her clothes and wants to know what kind of day will allow her clothes to dry quickest: a sunny day, a windy day, a snowy day or a sunny and windy day.***

Hypothesis: ***Clothes dry better on a windy day.***

The children have to explain their prediction: *I predict that… because…*

Video clip 9 shows Naeem Mohammed (pictured here) using a scenario related to which type of vehicle uses the most fuel to help his Y6 class both have the scientific knowledge and the ability to express it clearly so that they can talk like scientists. It also shows just how engaging Yew Tree's approach to science enquiry can be. The quality of the dialogic teaching is reflected in the pupils' ability to discuss ideas in pairs, then share ideas and listen to the ideas of others.

How Warren Road helps the children talk their way to understanding the scientific content of a unit is clearly illustrated by the Year 2 children's enquiry unit about plants, introduced on **page 6**.

Once the vocabulary and key skills of the unit had been established, the children were given a selection of fruits with seeds to cut open and look at the seeds. They were asked, ***"What do seeds need to grow?"*** The teacher elicited ideas from the brainstorm.

They were then presented with these three contradictory statements and asked what they thought:

- ***"The seeds won't grow until I put them in the dark."***
- ***"They will start to grow better under a bright light."***
- ***"The amount of light doesn't make any difference."***

After that, they were given this question to test through a comparative test: ***"Do seeds need light to germinate?"*** This led to discussion about the following questions:

- ***"How could we find out?"***
- ***"How will we know which set of seeds has grown the best?"*** (Measure height, count number that has germinated.)
- ***"How often should we check them?"***

Following this discussion, the class was helped to set up a comparative test using cress seeds because they germinate quickly. In small groups, they set up three dishes: one to go in the dark, one to go in a bright light and one to be the control.

The children then discussed what variables they must keep the same and why this was important (the amount of water, air, warmth, number of seeds, types of seed). After this, the children used a text map to help them predict and hypothesise verbally and then record in their books with a picture of the seeds.

The children's learning was then embedded through relating it to the science toolbox, as explained in the next section.

4. Co-constructing toolkits to develop the key skills of science

Understanding scientific enquiry is the underpinning skill that should be progressively built up throughout the science curriculum. Working scientifically means building all the key science skills which form the tools of science, just as the writing toolkits underpin how to write in English. At Warren Road, Tamara uses co-constructing science toolkits to help the children build confidence with the language of science so they can begin to think and work scientifically. The teacher teaches all these skills progressively to help children build their science toolkit so they know which tools to use to conduct different types of enquiry, for example:

- make careful observations;
- use relevant scientific language;
- make a prediction;
- hypothesise;
- set up simple tests;
- draw simple conclusions;
- present results clearly;
- measure accurately using different equipment;
- gather, record, classify and present data in different ways;
- report findings precisely and accurately.

Every science lesson the teachers will say, ***"What skills did we use today? Are they in our toolkit?"***

The children discuss this and look at the toolkit and add any additional skills needed. The answer might be that they observed, measured and drew conclusions.

This begins very simply as the Reception *Curious Chameleon* toolkit here illustrates. Images and icons help the children recognise that being a scientist is based on asking questions and finding the answers carefully.

The next time you do an experiment, you have the range of scientific tools needed and you just select the appropriate ones from the toolkit. Some of the skills are generic to every science enquiry so you will always use them – like using the relevant scientific vocabulary which is included in every science toolkit and first appears in the Reception toolkit.

Explorify (see Explorify.uk) is an excellent source of material to both maintain children's interest and build up science toolkits. For example, the Year 2 unit on plants includes a video of a seed germinating. The children were asked to watch it and explain what was happening. The teacher wanted to establish if they knew that they were looking at a seed.

They were asked a range of questions:

- ***"Can you describe what the seed looks like?"***
- ***"What do you notice about the soil – is it wet or dry?"***

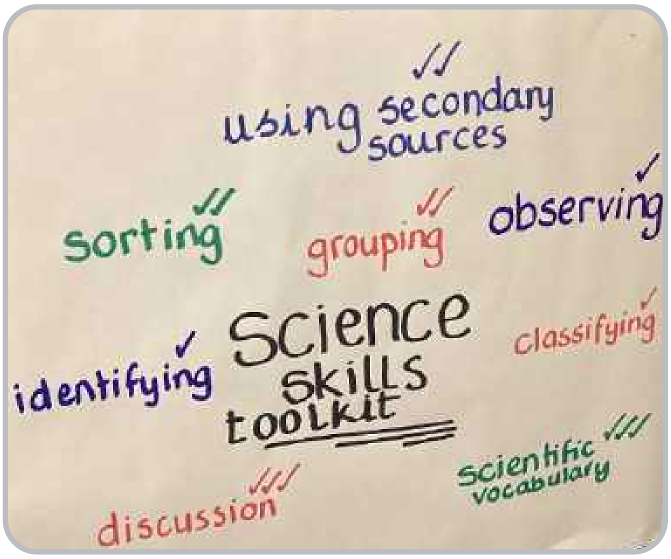
They then acted out the germination of a seed – devising an action for every stage.

The children were familiar with the concept of a science toolkit from their work in earlier lessons. So, they were then asked what science skills they had been using in their lesson. Through discussion, the children added **observing**, **scientific vocabulary** and **classifying** (sorting). They were then told that they were going to be gardeners and have an allotment. They discussed what they would need to do to look after the plants. The teacher drew out from them what they thought plants would need to grow well.

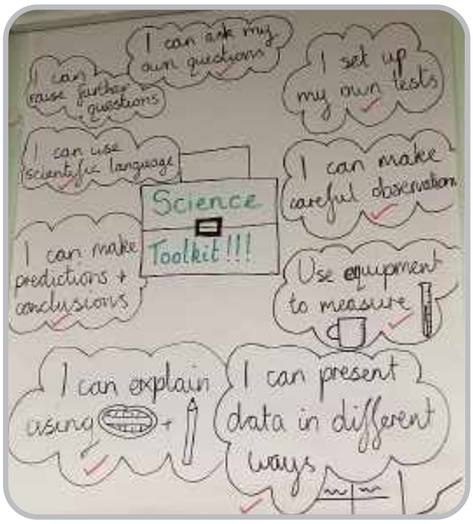
Each child then chose a plant and predicted what they thought it would look like in two, four and six weeks' time, and came up with a hypothesis based on their prediction using the actions for prediction and hypothesis that they were already familiar with. They then drew what they thought their plant would look like at each predicted stage and labelled it. The plants were then planted – keeping back 15 plants to investigate later.

Over the course of the unit, the children were given weekly opportunities to observe the plants and tend them to keep them healthy. They redrew their chosen plant after set time periods.

The children then discussed what skills were used in the lesson and were they already in the toolkit. This allowed them to add significantly to their science toolkit since some skills could be ticked off while new skills needed to be added to the toolkit as illustrated here.



They were already familiar with *predicting* and using the action for prediction and hypothesis but now they could add: *identifying the type of investigation – observing over time*.



Through building up the toolkit through a range of investigations over the years, you innovate on using the tools so that, over time, the children can use each tool independently.

The underpinning focus of the toolkit remains the same but it becomes more sophisticated in line with the age-related expectations of science enquiry, as illustrated by this Year 5 toolkit.

Tamara introduced this approach at Warren Road in 2022 and found that it quickly made a big difference. Tamara now uses this in the science training she provides for STEM and it has proved to be the most popular takeaway – teachers love it. It makes integrating working scientifically into lessons easy. The more confident the teachers become in understanding the underpinning skills of science, the better they will be able to build the children's understanding and confidence.

After seeing these toolkit examples in online training, one teacher commented:

> ***"This is great as I find that pupils can remember vocabulary and knowledge but the science skills and how they perform enquiry is often lost year on year."***

Warren Road's toolkit approach develops all three aspects hand in hand.

As explained on **pages 15-16**, at Yew Tree the key science investigation tools are repeated and developed from Year 1-6 and form the underpinning science toolkit.

For example, for a fair test there would be a change of variables. Children will need to understand that in this investigation they must only change one variable and consider which variable they are going to measure. The teacher assesses whether the children understand the key concepts of fair testing. Following a brief discussion in pairs, ideas are fed back to the class with the teacher addressing any misconceptions.

Fair test



Which material would be most suitable for an umbrella?

Changing variable: type of material.
Controlled variables: size of material, size of umbrella, thickness of material, umbrella is tested in the same climate or weather.
Measuring variable: which material absorbs the least amount of water.

The Year 5 example here asks, ***"Which material would be most suitable for an umbrella?"***

Children are then asked to suggest the variables.

Changing variable: ______________________
Controlled variables: ____________________
Measuring variable: ______________________

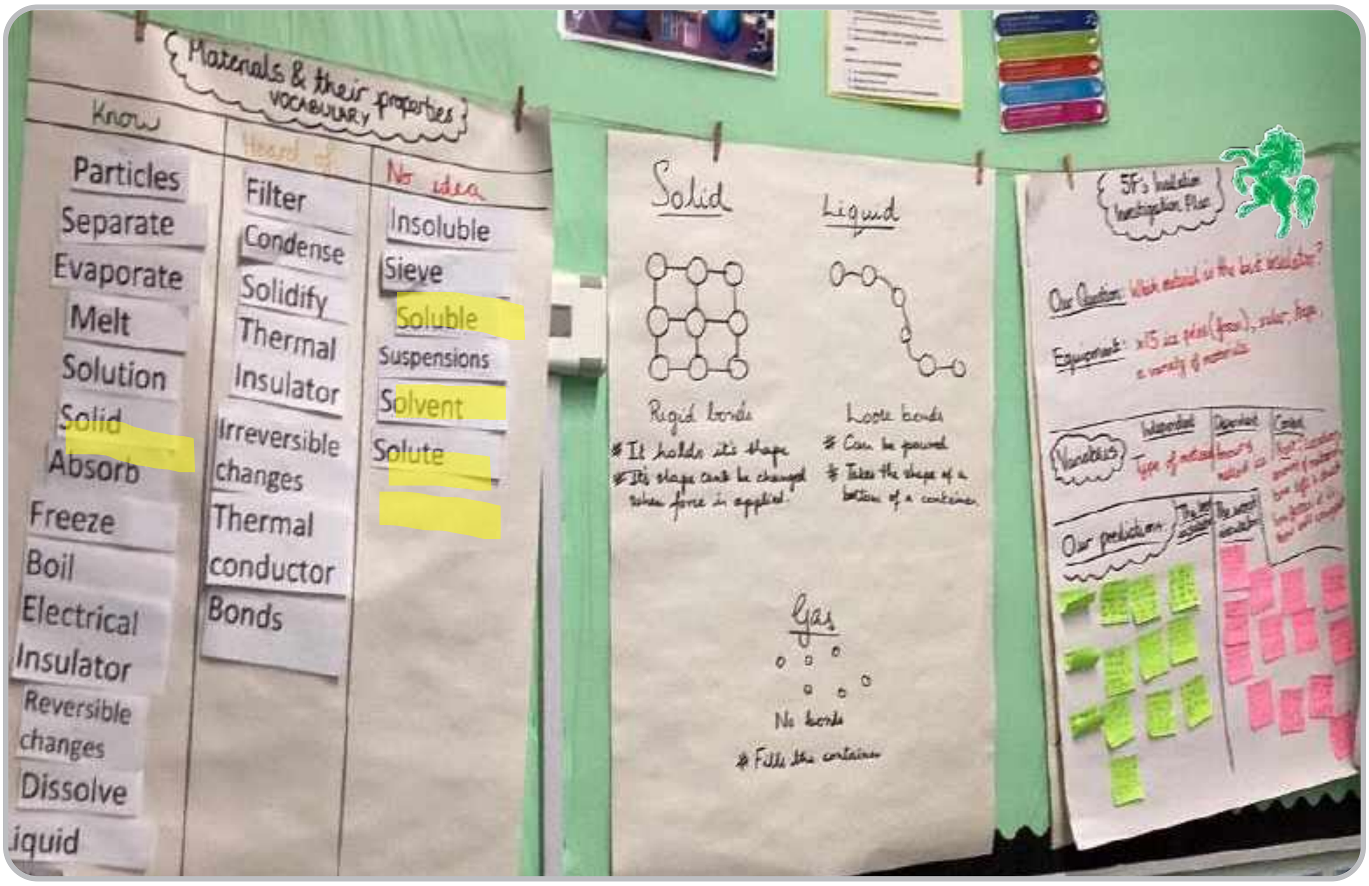
The variables would be hidden from the pupils and revealed after a quick discussion. The teacher might provide one or two depending on the class.

This consistent exposure, through a variety of scenarios from Year 1 to Year 6, allows children to internalise and become confident in making informed decisions about variables and the enquiry types they should choose to build and interrogate their knowledge. This enables them to identify and apply the appropriate underpinning science tools that they need to use.

5. Making the learning visible

At Warren Road and Yew Tree, co-constructing a science working wall to illustrate and consolidate understanding is an essential part of the process. Learning must be visible.

Below you can see how the working wall for a *States of Matter* unit at Warren Road reminds the class of the key words they knew and the words they need to focus on. It also provides images of the different shapes of solids, liquids and gas, as well as the question they are investigating: "***What material is the best insulator?"*** Just as importantly, it includes the key points arising from the related discussion.



At Yew Tree, science working walls in classrooms exemplify the children's learning while the corridors are used to promote interest in science.

6. Internalising model text to support understanding, expression and retention

Model text, represented by text maps, underpin learning in science throughout the **Imitation Stage** just as they do in English. Such models can both provide children with the recyclable patterns of language needed for science enquiry alongside the related scientific information, as illustrated by the model text below to support Reception science work on Space at Selby Community Primary School, North Yorkshire, another TfW training centre.

Model Information Text on Space – Reception Class

Planet Earth: *We live on Earth. Earth is a planet. It is surrounded by space.*

The Sun: *The Sun is a big bright star. It gives Earth light and heat.*

Day and Night: *We have day and night because the Earth slowly spins around. When our part of the Earth faces the Sun, we have daylight.*

The Moon: *At night, we see the Moon in the sky. The Moon does not give light. It is lit by the Sun.*

Moving Moon: *The Moon goes around the Earth. It takes 27 days for the Moon to go around the Earth.*

The Stars: *At night, we see the stars. Stars make pictures called constellations.*

The Solar System: *The Earth, the Sun and the Moon are part of the Solar System. There are seven other planets in the Solar System.*

The Universe: *The Solar System is part of the universe. The universe is huge. It contains billions of stars and planets.*

The central purpose of this model text was to help children understand the solar system alongside being a simple model for how to express information in science. You immediately know that it is intended for a very young class because all eight short paragraphs are full of short, simple sentences introduced by a highlighted heading, so the content and its structure is very clear.

The children were not given the written model but rather the text map of images that represented the model text, including a few key words. A small section of the text map is pictured here.

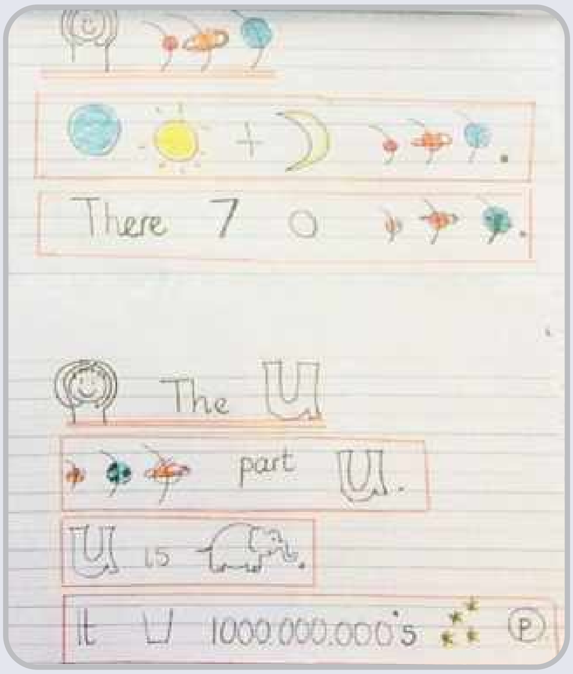
As you can see, the paragraph heading is introduced by a heading symbol and each sentence is given its own box with a full stop at the end. The images enable you to begin to *read* it straight away even if you cannot decipher the words and it helps the children become familiar with how written information is structured.

If you look here at the last two paragraphs of the actual text, next to the text map that represented it, you can see immediately how powerful the text map is in helping you understand and remember the content of the text.

Model Information Text on Space – Reception Class (last two paragraphs)

The Solar System: *The Earth, the Sun and the Moon are part of the Solar System. There are seven other planets in the Solar System.*

The Universe: *The Solar System is part of the universe. The universe is huge. It contains billions of stars and planets.*



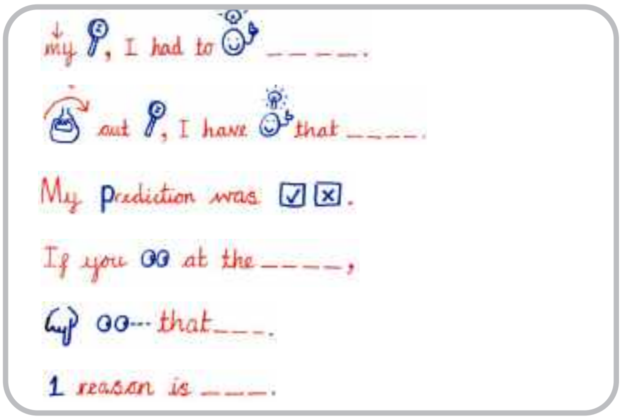
You might be thinking that this is too hard for Reception children, or that it would not engage them but the children at Selby Community Primary loved this unit. Once they had internalised the text, they took the text maps home with an accompanying letter to parents asking them to take photos or videos of the children using their text maps to help them describe the universe.

One parent kindly sent in this video of her son (**see video clip 10**). It is a useful clip to show for staff training as it convinces you of the power of this approach in helping children understand and develop interest in the world around them, alongside understanding how to express themselves clearly. A question you might want to ask, if using this clips for training is: ***"What does this clip tell us?"***

The images here were sent to the school by one child's mother. One glance at these images of this child's performance says it all: the enjoyment, engagement and sense of success shines through.

Science text maps that help children explain the findings of their enquiries lie at the heart of science units in Yew Tree. The colour-coding of the text map highlights the recyclable language of science investigations. These grow in difficulty across each year and across the years. As the science investigations become more sophisticated, the earlier science text maps act as a sort of **Imitation Stage** that is then innovated on and developed as the children grow older.

At the start of each session, the appropriate science text map for the age of the class is revisited so the children internalise the ***recyclable phrasing*** of science investigations (indicated in red in the Yew Tree text map here, and in blue on the transcript below and throughout this resource as explained on **page 19**). Once these recyclable phrases have been internalised, the children can then apply them to all their investigations. This imitation is done in TfW style, so it is visual and kinaesthetic with actions and sounds directly linked to the science scenario. This enables the children from an early age to talk like a scientist.



The Year 1 science enquiry text map above is used for all the enquiries in that year. In the first two terms the children focus on their predictions. By the summer term, they add on an explanation for the prediction. So, by the summer term, when investigating if materials are waterproof, the text that the children would say has been written in full below.

In my investigation, I had to find out if all materials are waterproof.

After carrying out the investigation, I discovered that my prediction was right/wrong.

If you look at the table/diagram/graph, you can see that the cotton allowed water to go through but the plastic jacket did not.

(Add on in the Summer Term)

One reason for this is that waterproof fabric has very small holes so that even water cannot go through it.

Children are then able to reflect on whether or not their prediction was accurate and pose reasons for the results. The children then use the text map to scaffold their verbal evaluation.

Video clip 11 shows a Year 4 class practising the language of science enquiry.

By Year 5, the science enquiry text maps look like this:

After conducting an investigation based on the hypothesis that…, it is my conclusion that… as I had predicted correctly/incorrectly. To support this, refer to the table, which shows clearly that…

However, compare this to the… A possible reason behind this could be that… In order to confirm the accuracy of these findings, I will…

Video clip 12 shows how the approach is used to help the children talk their way to understanding. Because they are familiar with the language of science enquiry, the children can discuss their ideas coherently. This approach helps Yew Tree to focus on deep learning rather than rushing through content coverage as the children are familiar with the language of science enquiry and can apply it to different circumstances.

Warren Road, at the time of writing in Spring 2023, used text maps more to embed the knowledge of science, as illustrated by **video clips 13 and 14**, rather than the tune of science enquiry. But Tamara, having visited Yew Tree, loved how they were using text maps to embed the language of science enquiry and discussed this with her team who are now very keen to trial it.

Video clip 13 is a Year 2 class from Warren Road showing what they know about the seven things that all living things have to do to survive. It powerfully demonstrates the power of internalising text to help pupils understand and retain knowledge. These seven things being represented by the acronym MRS GREN, as illustrated here. A question you may want to ask if you use **video clip 13 or 14** for training is: ***"How might this help children engage with and retain their learning?"***

Video clip 14 also from Warren Road shows a Year 5 class imitating a model text about solutes and solvents.

The really useful thing about internalising model text is that it supports the understanding and retention of the content alongside developing the tune of whatever is the subject focused on, in this case the tune of science enquiry. It therefore also supports pupils in applying what they have learnt to different scientific enquiries – so it exactly supports the three key aspects of learning: the content (substantive knowledge), its application (procedural knowledge) and the tune of the subject (its disciplinary literacy). In addition, since the model is related to science enquiry, it also supports how we can verify the knowledge (disciplinary knowledge).

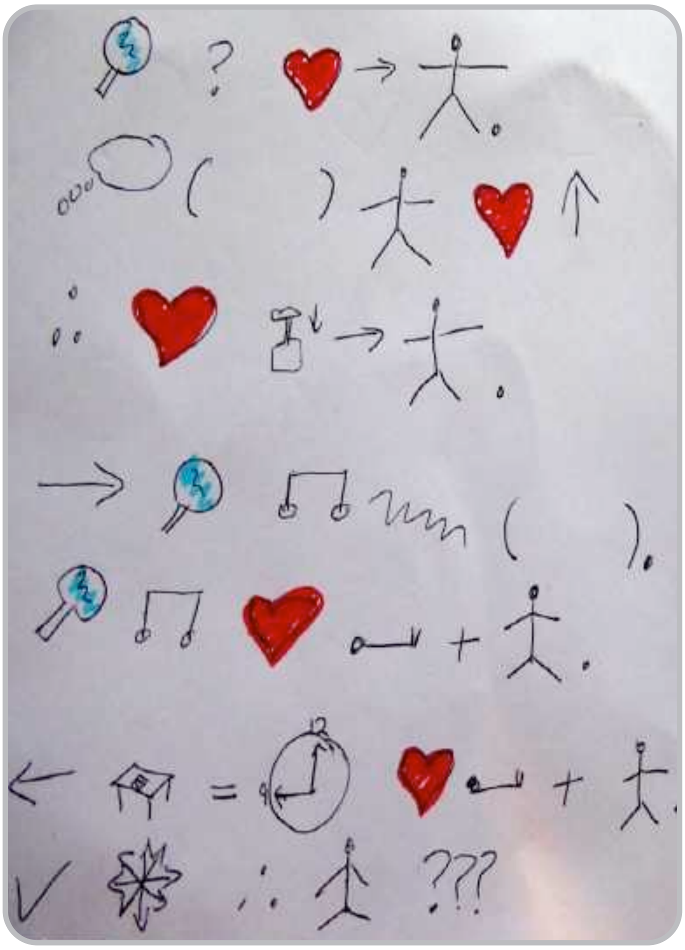
This can be illustrated by looking at this text map of an investigation into how exercise affects the heart. This text map represents this written text:

I am investigating what happens to my heart ***when*** *I take exercise.*

My prediction (what I think will happen) is that exercise will make my heartbeat faster ***because*** *the heart has to pump blood faster to enable me to do the exercise.*

To carry out an investigation, you must compare a dependent variable to see how it changes in a different circumstance (known as the independent variable) For this investigation, I will compare my heart rate (the dependent variable) ***when*** *I am resting* ***and when*** *I am taking exercise.*

However*, it is important to make the test fair which means that all the other variables (the controlled variables) must remain the same. To make this test fair, I must record my heart rate for exactly the same amount of time* ***when*** *I am resting as* ***when*** *I am exercising. It is essential that all the other conditions remain the same* ***because, otherwise,*** *I wouldn't know if it was the exercise or something else that was making the difference.*



If the children have first carried out the investigation, so that the process of conducting the investigation is familiar to them, alongside having built up the recyclable tune of science investigation across the years in Yew Tree style, they will have internalised the ***recyclable text*** of science investigations including those very important ***recyclable generic linking phrases*** (which together represent the recurring tune of science investigation that is transferable from one investigation to another). This allows the children to focus on the specific content related to the investigation they are conducting. If the colour-coding of the recyclable text, as illustrated above, is co-constructed with the children once they see a written version of the model text, this both helps the children internalise the tune of science investigation and recall the knowledge related to the specific investigation, which now remains in standard black text.

The power of this in practice can be illustrated by a Year 6 enquiry at Yew Tree into the relationship between the strength of a plant's tendrils and the fruit that it can bear.

The first part of this classification enquiry was to check the children's understanding of *tendrils* based on their learning from the previous year. Then, the question was posed: ***"Which plant has the strongest tendrils?"*** Initially, the children used the photographs and prior knowledge to make their predictions in pairs or small groups. These predictions were then rehearsed verbally using the investigation text map below. Then, the teacher revealed the results of the investigation in the form of a table as pictured here.

Plant	Maximum weight held by tendrils
Pea	300g
Pumpkin	1kg
Cucumber	500g

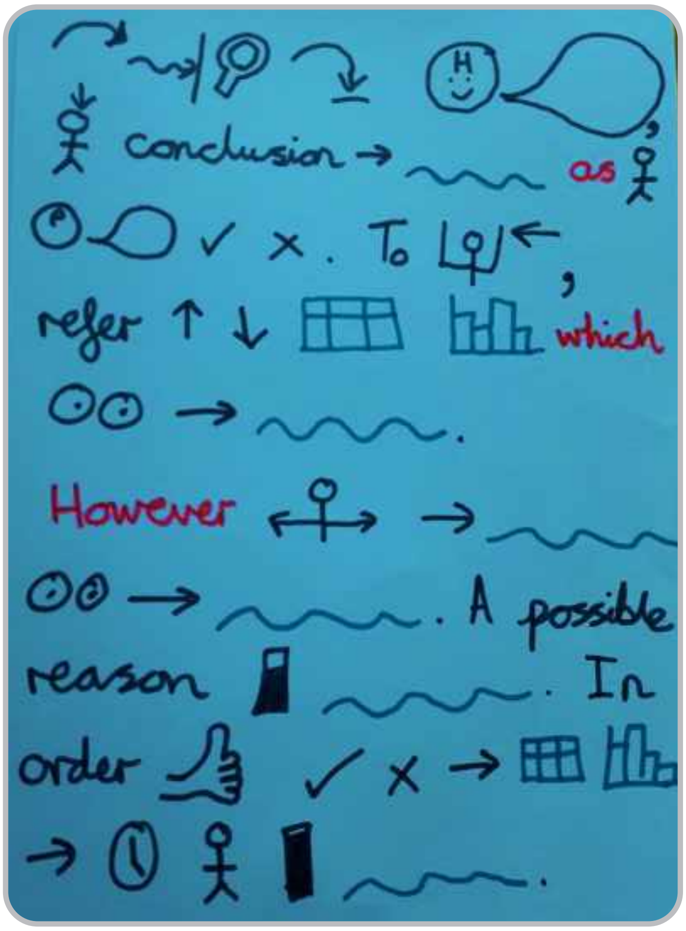
Next to the text map below is the transcript of a child's explanation when using this text map. The ***recyclable text*** has been colour-coded to illustrate how helping children internalise the recyclable pattern of science investigations helps them express their scientific understanding coherently.

After conducting an investigation, based on the hypothesis that the plant that bears the fruit with the greatest mass will have the strongest tendrils, it is my conclusion that the pumpkin had the strongest tendrils as I predicted correctly. To support this, please refer to the table above which shows clearly that the pumpkin plant held a mass equal to 1kg.

***However**, if you compare this to mass held by the tendrils of pea plant, you will see that it only held a mass of 300g. A possible reason for this is that the pea produces very light pods and therefore has not evolved to withhold greater weights.*

In order to check the accuracy of my hypothesis, I will repeat the investigation with three different plants that differ in the mass of the food they produce.

Oral explanation by Awaal, Year 6



If anyone still doubts the power of text mapping both to engage children and support their learning, then **video clip 15** is the one to show. Here Tamara, hiding in the left-hand corner of this image, is leading her Year 6 class in a glorious celebration of pollination! A good question to ask if using this clip for training is: ***"How do we know these children understand pollination and will retain their learning?"***

How text mapping content supports retention

Anyone using TfW in their English lessons will be familiar with text mapping as a tool for helping to internalise the language of model texts, but text mapping is also the perfect way to help children both understand and retain key content in any subject and is, therefore, very useful in science.

Encouraging children to create images to represent the key vocabulary, phrasing and content of a science investigation not only helps them understand and retain the meaning of those words and ideas but it also enables them to quickly text map any related text, which in turn will help them retain the information. Moreover, because text mapping makes you think about how information is linked together, and science is all about what causes what, it is a significant asset for learning science, as the example below demonstrates.

Text-mapping content promotes understanding and retention

Rainbows

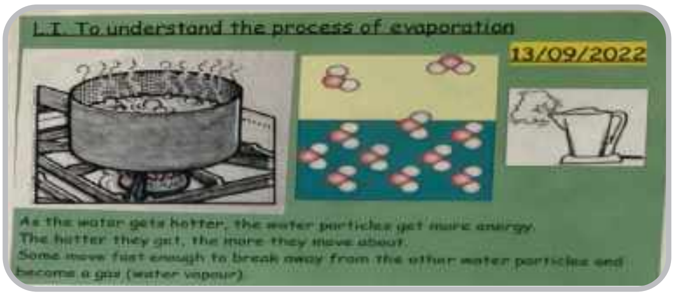
If the sun comes out when it's raining, a rainbow appears in the sky. To see the rainbow, stand with the sun behind you and the rainy sky in front of you, because rainbows form in the sky opposite the sun.

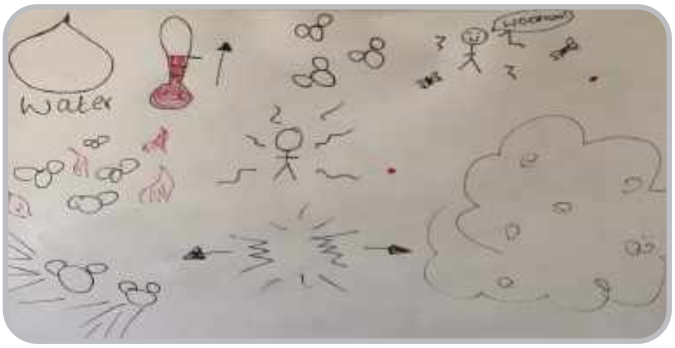
If someone dictated the text on this *Rainbows* slide to you, you could probably write it down automatically without thinking about the content but, if they gave you two minutes in which to text map it, you would have to focus on the content, and decide how to represent the relationship between the elements of the information. Try it. Suddenly the sentence signposts and imperatives come alive with meaning as you attempt to represent that meaning: your images illustrate how to position yourself to see a rainbow and how the pieces of information in the text are related.

We asked the online audience to comment on why this approach was so powerful. A few of their many comments are presented here. It is worth reading these carefully:

- ***"I had to listen very carefully."***
- ***"Being able to visualise the text makes it more meaningful."***
- ***"Forces you to really think about the meaning of words and how they are connected."***
- ***"The drawing helps you imagine the process happening."***
- ***"Because they have to consider every word, which will embed the learning, it helps those who struggle to articulate the learning and to read notes from a lesson."***

If you have never tried getting your class to text map content, try it – it works. Just as with text mapping model texts in English, get the children to quickly jot their own images. If you have a look at the information on evaporation below from Warren Road and then at the text map that a child made to represent the information, you can see how text mapping helps you understand the content.





7. Boxing-up the structure of science enquiries

In English, boxing up the structure is a very important part of the TfW process as there are so many different story/non-fiction writing structures that the children need. It is very easy to transfer how important boxing up structure is to science as this boxed-up planner for a science investigation illustrates. And, in science, versions of this can be used for every investigation.

Underpinning structure	Science investigation
What is being investigated	
Prediction	
Variables	
Making the test fair	

Within Yew Tree's approach, the underpinning structure of science investigations remains constant across the years but the focus of the investigation and its related language becomes more sophisticated. In effect, the recyclable investigation sentence stems provide the structure for both the spoken and written expression of the children's understanding.

It is obvious how this process will support the writing up of scientific enquiry but, since the focus of science enquiry in primary schools is liable to be more oral than written, it is also the perfect way to support children in coherently explaining what they have investigated, as the slide here for oral work at Warren Road illustrates.

Year 2 Boxing-up and text mapping your oral conclusion		
Was my prediction correct?	I thought the ice cube on the radiator would melt the quickest. I was correct.	
Pattern/link between independent and dependent variables	The hotter the surface, the quicker the ice cube melted.	
Issues with investigation	The ice cube fell behind the radiator and got covered in fluff. We had to wash it.	
Changes you would like to make	Next time, I would stop the ice cube falling behind the radiator and I would like to try wrapping the ice cube in a scarf to see the effect on melting time.	

8. Consolidating learning at the end of the Imitation Stage

It is important to consolidate all the learning in the **Imitation Stage** before moving on to the **Innovation Stage**.

At the end of the **Imitation Stage** for the Year 2 unit on plants, once the seeds had germinated, the children looked at their three different seed groups to establish what they showed. They discussed this in small groups and looked to see if there was a pattern.

The teacher explained that as scientists they need to explain the results of their experiment clearly – this is the conclusion that sums up what the experiment tells us. It is at this point that the text map of the model text with its focus on the recyclable text of science enquiry is so important. The text map enables the children to structure their conclusion verbally.

Through shared writing, the class was then able to co-create a class conclusion – which enabled the children to write their own. The teacher then helped the children to record their finding in their books by drawing a bar graph that showed how many seeds germinated in the dark, in bright light and in normal light.

To embed their understanding of the **Imitation Stage**, the children were then shown three different fruits and asked to identify the odd one out.



They were then asked these questions:

- ***"Do they all grow in England?"***
- ***"What is the weather like where they grow?"***
- ***"How could we find out?"***
- ***"What part of the plant are they?"***

They were then asked to match the tree to the fruit.



This elicited a discussion about how seeds/plants grow in different places with different conditions. The children then looked up what countries the plants/trees grew in.

As mentioned on **page 22**, the science toolkit was revisited at the end of the **Imitation Stage**. The children were asked to identify what skills were used in the lesson and to add any of the skills that weren't already in the toolkit.

The teacher helped the children recognise the type of enquiry – **Comparative Test** using secondary sources – alongside ensuring the children knew the action for this type of enquiry.

Chapter 2: The Innovation Stage

Now that the knowledge has been warmed up, and the enquiry type consolidated alongside the science enquiry text map, the children at Yew Tree are ready to move on to a related enquiry, innovating on their understanding.

The teacher uses a range of strategies to deliver the subject knowledge (visually, verbally, kinaesthetically, through discussion and practical application) before asking the children to strengthen their understanding through a practical enquiry. Because the vocabulary, prior-knowledge and enquiry type is 'warmed-up' at the start of the **Innovation Stage**, all the children are able to access the learning and become secure in their understanding of the new scientific content.

Video clip 16 shows a Year 4 class embedding their understanding of pattern seeking at the start of the **Innovation Stage** before innovating on their understanding. This transcript and related screen grabs illustrate the power of this approach.

Teacher: *How do we show pattern seeking?*

Children: *Pattern seeking.*

Teacher: *How many variables?*

Children: *4.*

Teacher: *What's the extra variable that pattern seeking has?*

Children: *Uncontrolled variable.*

Teacher: *Can you please show me predict?*

Children: *Predict.*

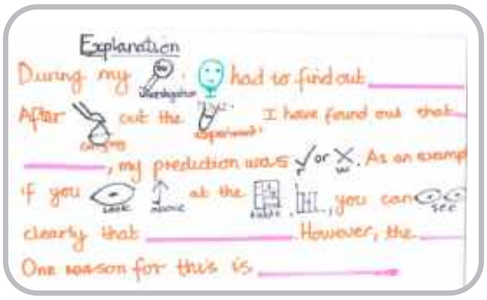
Teacher: *How do we show research?*

Children: *Research.*

Teacher: *And how do we show result?*

Children: *Result.*

Video clip 17 shows how the same Year 4 class has internalised the ***recyclable text*** for an investigation (illustrated here) including how to explain the findings so that when they innovate, they can explain their findings coherently using the appropriate scientific terminology.



The children then plan and carry out their enquiries,

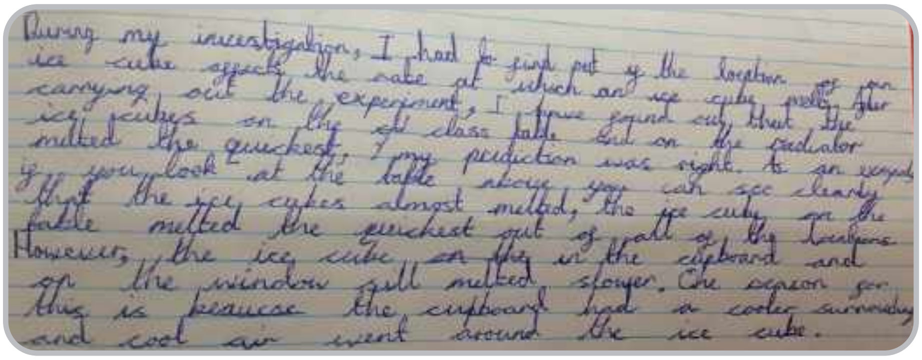
following which they explain their findings using the science text map and inserting key aspects such as data and the results from their investigation.

Pupils write up their data and evaluation using the text map to scaffold their answers. This part of the lesson is supported throughout by the teacher, with independence being handed over to children gradually. For example, children begin to select their own variables, materials, presentation of data, etc.

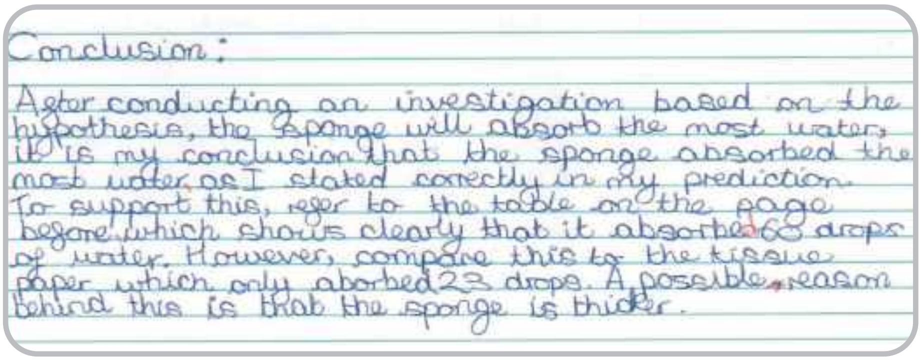
In one Year 6 class, the pupils placed a variety of leaves in water and then measured the weight of each leaf after a specified period of time. After measuring and collating their data, children discussed what had occurred and why. Having internalised the investigation text map, the children were able to write up their results appropriately, using a clear structure.

Children working at *greater depth* will naturally progress from using every aspect of the model text to using it only as a reference point. However, those less confident in their understanding of the scientific concepts, or those who are still new to English, will hug closely to the structure. After practising using the text map orally, children write their explanation.

You can see from the examples below, that the children quickly absorb the language of scientific enquiry and adapt it to suit the findings of their enquiry so that they can explain their findings coherently.



During my investigation, I had to find out if the location [illegible] ice cube affects the rate at which an ice cube melts. After carrying out the experiment, I found out that the ice cubes on the class table melted the quickest, [illegible] my prediction was right. [illegible] If you look at the table above you can see clearly that the ice cubes almost melted, the ice cube on the table melted the quickest out of all of the locations. However, the ice cube in the cupboard and on the window sill melted slower. The reason for this is because the cupboard had a cooler surrounding and cool air went around the ice cube.



Conclusion:

After conducting an investigation based on the hypothesis, the sponge will absorb the most water, it is my conclusion that the sponge absorbed the most water as I stated correctly in my prediction. To support this, refer to the table on the page before which shows clearly that it absorbed 68 drops of water. However, compare this to the tissue paper which only aborbed 23 drops. A possible reason behind this is that the sponge is thicker.

The progressive text maps help overcome a key obstacle for pupils: they provide the key stems linking the explanation – rather like the cement holding the bricks in a wall.

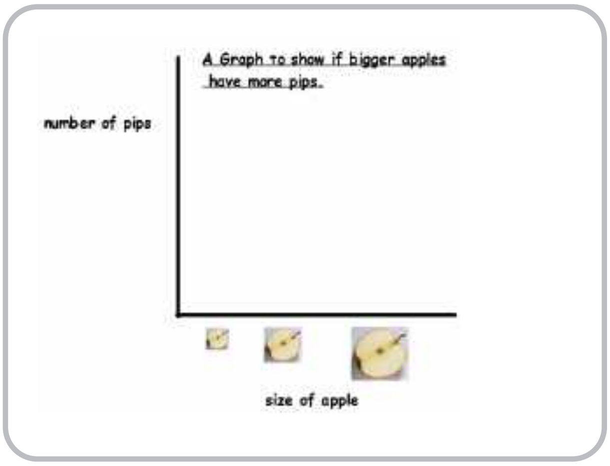
Similarly, at Warren Road, the **Innovation Stage** enables the children to build on the knowledge they have established in the **Imitation Stage**.

The **Innovation Stage** for the Year 2 unit on plants began by asking the children to name their favourite fruits. This helped embed a learning intention of the unit: that the children should be able to display the results in a graph form.

The children first created a human bar graph of the results. The teacher then showed the children what this would look like when represented by a bar graph. The children were then given the 'Big Question': ***"Do bigger apples have more seeds?"***

Each pair of children was given a small, medium and large apple to look at and handle before brainstorming their suggestions as a class. The children then discussed these ideas and hypothesised. They then used the text map to help them discuss what their enquiry would look like.

They were asked what type of enquiry this would be so the children began to consider how you would discover whether *bigger* and *more* were related in this situation and that they would be *pattern seeking*.



The teacher posed the key question: ***"How could we find out?"*** The children were then told that they were going to cut the apples open and then create a bar graph on their desk of the results.

The teacher modelled using the boxing-up grid on flipchart paper and added it to the science working wall.

The children verbally made conclusions supported by the text map. Some also wrote their conclusions on the desk next to their graph using white-board pens.

Again, this stage ended by referring to the science toolkit. The children discussed what skills were used in the lesson and added any skills that were missing.
(*Classifying*, *observing*, *scientific vocabulary*, *asking questions*, *predicting*, *hypothesising*, *concluding*, *displaying results*, *collecting results*.)

Finally, the teacher checked that the children had recognised the type of investigation – *pattern seeking* – and made sure the children knew the action for this type of enquiry.

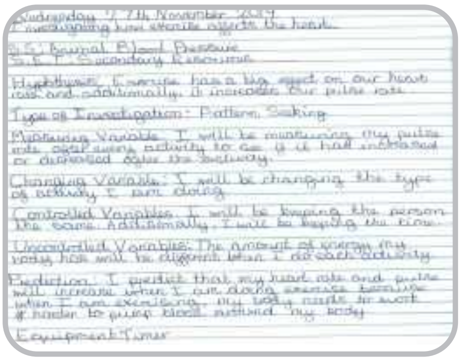
Chapter 3: The Independent Application Stage

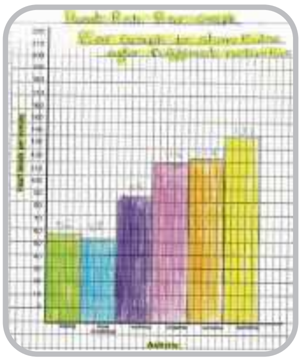
1. The Hot task

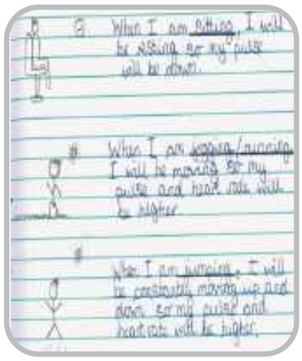
The final stage of the process provides the pupils with the opportunity to show what they can now do independently. This is often known as the ***hot task*** when children apply what they have learnt in different circumstances, for example a different context, a different question relating to similar content, a different problem to solve using the same method as the one that has just been learnt, or the opportunity to create something independently. Depending on the unit, preparation for this final stage will vary. In some situations, just as in English, feedback from the **Innovation Stage** may mean that key skills need embedding before the ***hot task*** can begin.

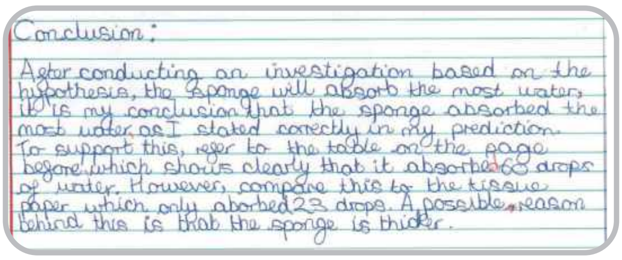
At the end of a unit of work at Yew Tree, pupils are provided with a related scientific question. They then devise their own prediction, hypothesis, enquiry type, method, data collection and evaluation, as illustrated below by an example from Year 6 investigating the effects of exercise on the heart.

This approach challenges the children to draw on all of their learning within that unit, as well as their understanding of scientific enquiries themselves. The children were encouraged to think critically and make multiple decisions for themselves, all the while justifying their choices. The pupil's work pictured below shows how the investigation was structured, alongside some of the evidence resulting from the investigation and the conclusion that was drawn.









For many teachers (and pupils), allowing this much freedom within a lesson can be daunting. However, because of the systematic teaching of the knowledge and enquiry-type throughout the units across the years, the lessons build the knowledge and skills to enable the children to rise to the challenge. Moreover, the very nature of the open-ended task provides a wealth of assessment opportunities for teachers. They then use this to plan their next unit of work, adapting their teaching to ensure any misconceptions are addressed (both in terms of knowledge and understanding of scientific enquiry). And, most importantly, the children love science. Their success in explaining their findings boosts their confidence across the curriculum.

The **Independent Application Stage** at Warren Road follows very much the same route – the children may be challenged to apply all that they have learnt in the unit to a new related situation or they may have to pull together what they have learnt and draw conclusions.

For example, the final stage of the Year 2 unit on plants began with the children being shown pictures, in weekly sequence, of the plants growing in the class garden. They were asked to compare this to the pictures that they drew at the beginning of the topic to represent what the plants would look like at two, four and six weeks. They were asked:

- ***"Do the photographs match their drawings?"***
- ***"Is there anything that they have been surprised by?"***

They then discussed how they had been caring for the plants. At the beginning of the unit they had discussed that plants would need space, light, water, warmth and air.

The teacher then presented the hypothesis: ***"Plants grow better if they have water."***

In pairs, the children were given two plants and challenged to devise a comparative test to test if their plants grew better with water. They discussed this question with their partner: ***"What should you do?"***

After discussing this in pairs, the class shared their ideas.

The children were then shown the previous boxed-up investigations on the science wall.

Each pair was asked to set up an investigation to test if their plants grew better with water. On their own planning grid, they needed to show:

- what they were going to do;
- what they were going to keep the same for both plants;
- how they would judge which plant has grown better.

They were told they needed to make a prediction and a hypothesis and take pictures of their plans for their books. The children then set up their investigations according to their plan.

Using the text map, the children independently either explained their conclusion to their water investigation orally or wrote it in their books; some children chose to do both.
To establish if they had embedded their understanding, the children were then given all the vocabulary cards related to the unit again (*leaves*, *stem*, *root*, *flower*, *berries*, *seeds*, *bulbs*, *fruits*, *trunk*, *evergreen*, *deciduous* and *germination*) and were asked to sort them into the categories below and take a picture:

Know	Heard of but unsure of meaning	No idea

Hopefully, all the words would now be securely in the *Know* category.

The teacher then played *call and response* to check the children's knowledge of the parts of the plants and their function. Finally, the children played taboo in pairs to consolidate their understanding.

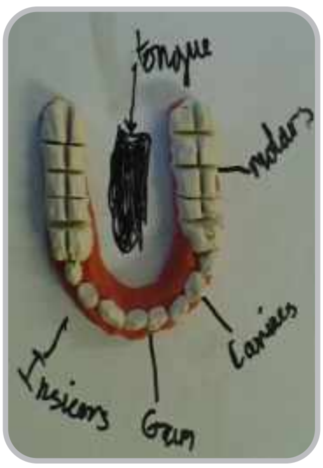
Making models to express learning

Hot tasks at Warren Road sometimes focus on making models to express what the children have learnt. For example, a Year 4 ***hot task*** required the class to,***"Use your learning over the last few weeks to create a scientific model of the digestive system out of plasticine."***

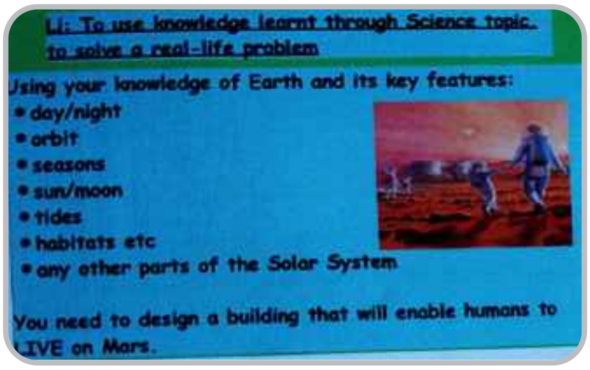
This tested two concepts. Could they include all the organs and explain what is happening at each point? Could they create a simple scientific diagram using labels and colours to explain how something looks or works?

As you can see from the picture, these two girls could – and doubtless enjoyed themselves while co-constructing their response.

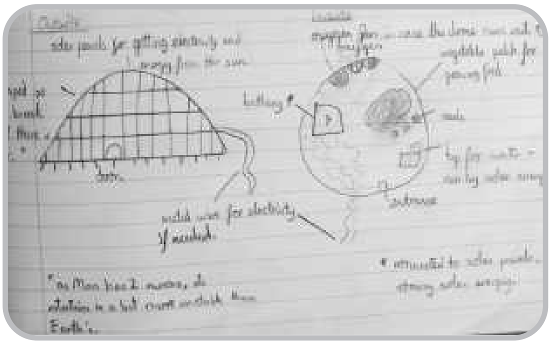
Sometimes the ***hot task*** is directly related to the ***cold task***. For example, for a Year 4 unit on the role of teeth, the ***cold task*** was to make a model of what the children knew about the role of teeth and label it, as the image (below left) illustrates. The ***hot task*** was exactly the same. The image on the right shows how the child's knowledge and understanding of the role of teeth has significantly increased by the end of the unit.



This image shows a Year 5 ***hot task*** at Warren Road with a focus on using the knowledge they have gained from the unit to solve a real-life problem.

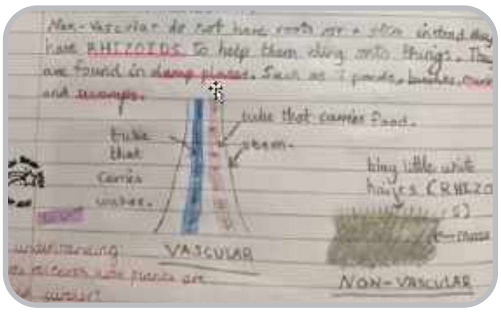


Below is one pupil's response to this challenging question:



The journey from ***cold*** to ***hot*** is important. A misconception identified by the ***cold task*** may continue as the children grow older as the following example illustrates. In a Year 6 unit on *Living Things and Habitats – Plant Classification*, the ***cold task*** was to identify the odd one out in these three images:

One pupil answered: ***"I think it is the moss because it grows and the others don't."*** Fortunately, the ***hot task*** shows that the unit impressively corrected this misconception. This time the pupil wrote: ***"It is the moss because it is non-vascular and the other two are vascular. I know this because it doesn't have a root or a stem."***



Conclusion: Building in progression

The strength of the Yew Tree science curriculum is that the key TfW strategies have been adapted to suit science and are progressively repeated from year to year. This enables the children to internalise them and use them for structuring their own work alongside supporting their ability to explain their learning coherently:

"Securing real progress happened when Talk for Writing was strategically taught across the curriculum. In science, the systematic structure for teaching allows
- less confident teachers to become secure in the delivery
- pupils to routinely build on their prior knowledge, deepen their understanding of new concepts and commit their learning to their long-term memory.

Consistently, the school can see the impact on pupils' understanding of complex scientific concepts combined with their ability to pose questions, seek to find their own answers and reach their own conclusions in a scientific way. One of the most positive results has been the confidence and enthusiasm that flows from all pupils when they are presenting or explaining their ideas."

Nasrin Ahmad and Michael Rayner

In Warren Road, an already strong approach to teaching science supported by Explorify and STEM resources has been further strengthened by integrating the underpinning pedagogy of TfW into how the children are taught. Now the children and their teachers are confident with the vocabulary and precise language patterns of scientific enquiry. Text mapping helps them recall key content and they can now progressively co-construct the tools of science enquiry.

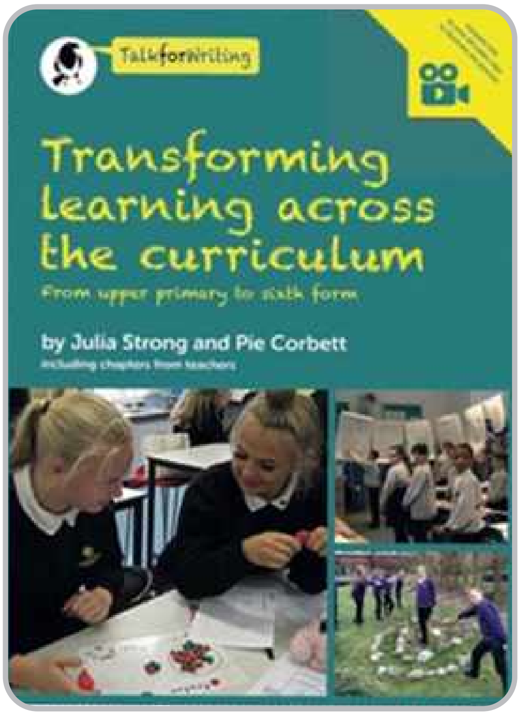
This enables the children's scientific skills to progress over time. For example, in Year 2, they start to use skills to carry out basic investigations. If it is simple, they might be able to set up their own investigation or the teacher might take them through the process. By Year 6, they ought to be able to come up with their own questions, decide what type of investigation they are going to do and then get the resources, organise the investigation, draw their own results chart, and present their results so that it suits the audience alongside writing their conclusion independently.

Appendix 1: Resources

- STEM (Science Tech Engineering Maths) see stem.org.uk – is an excellent online resource for primary science teachers.
- Explorify (explorify.uk) is an amazing science website that is free for schools.
- Ogden Learning Trust (www.ogdentrust.com) is another wonderful online resource supporting physics teaching.
- CIEC provides a range of curriculum-linked resources for the teaching and learning of the science curriculum.
- PSTT (Primary Science Teaching Trust) provides excellent ideas and resources.
- Twig Reporter is a weekly news round-up of all things happening in science at a primary level plus Big questions answered in a fun way.
- PLAN (Planning for Assessment) provides excellent sources for vocabulary, knowledge and skills progression. It also includes examples of key misconceptions in each unit to watch and plan for.

If you want to know more about how the underpinning pedagogy of TfW supports learning across the curriculum, see:

- ***How Talk for Writing supports Maths*** http://www.talk4writing.com/maths by Julia Strong and Pie Corbett – available spring 2024.
- ***Transforming Learning across the Curriculum*** by Julia Strong and Pie Corbett – available from https://shop.talk4writing.com/products/transforming-learning-across-the-curriculum.



"Who'd have thought Talk for Writing could make such a difference to maths, PE and science? Packed with riches, the powerful TfW approach is applied in this book to the entire curriculum by the experts Pie and Julia, with outstanding results. You will find everything you need to be transformative in developing students' language acquisition and confidence in writing, no matter what the subject. Detailed rationale, links with cognitive science, endless practical examples across the upper primary and secondary curriculum and exemplary chapters written by teachers: get started!"

Shirley Clarke, Formative Assessment Expert

Appendix 2: Why Yew Tree uses TfW to support science

More than 10 years ago, TfW became the driving force to change how Yew Tree Community Primary School in Birmingham ensured that children enjoyed English, particularly writing and retelling stories. Most importantly, it impacted on children's confidence: it built up essential skills, such as developing speech, the use of correct grammar and the enjoyment of reading alongside developing a wider knowledge of vocabulary and understanding. The leadership team knew that vocabulary was key to successful learning, particularly for their children, as the majority have English as an additional language and many are new to English. However, the benefits for all the children were apparent. Armed with good vocabularies, the speaking and writing skills of all the children improved. As a result, it became a TfW training school.

Securing real progress only happened when the leadership team ensured that TfW was strategically taught across the curriculum. They were proud of their achievements in English, but they knew they needed to ensure the same passion for learning was embedded for all areas of the curriculum. Knowing how TfW had impacted all areas of English, they utilised its potential and took the strategy right across the curriculum. In science, two lead teachers, Nasrin Ahmed and Michael Rayner, developed what this meant for science. They quickly recognised that the underpinning TfW process was perfectly suited to support the children in developing scientific enquiry skills. This enabled them to develop the approach and then support all the staff in delivering it.

Although the subject of science itself has its own pedagogy, Yew Tree has found that the TfW process has significantly strengthened its teaching of science. The systematic structure for teaching allows less confident teachers to become secure in the delivery. Moreover, it allows pupils to routinely build on their prior knowledge, deepen their understanding of new concepts and – perhaps most importantly – commit their learning to their long-term memory. Consistently, the school can see the impact on pupils' understanding of complex scientific concepts combined with their ability to pose questions, seek to find their own answers and reach their own conclusions in a sophisticated, scientific way. One of the most positive results has been the confidence and enthusiasm that flows from all pupils when they are presenting or explaining their ideas. Anyone who visits the school will immediately be impressed by the children's enthusiasm and their ability to explain their learning.

Appendix 3: Why Warren Road uses TfW to support science

Warren Road's journey towards using TfW to underpin how the school's teaching of science is different from Yew Tree's. Warren Road has very successfully implemented TfW in English for many years. Tamara Fletcher has been science lead at Warren Road throughout all that time. Initially, Tamara didn't use the underpinning pedagogy of TfW to support science so I asked her why she had changed direction and started using it, and what difference had it made. ***"I tried it and it worked!"*** she replied.

As science lead, she had always encouraged the use of actions, songs and drama to support learning in science but she hadn't used the cold-to-hot process, the specific work on vocabulary and the development of language patterns that TfW emphasises, text mapping or toolkits. Initially she tried text mapping the digestive system with Year 4 and it really helped them understand the process. So, she trialled the *cold* to *hot* process and that worked too. More recently she introduced science toolkits for working scientifically. This toolkit approach was only introduced at the beginning of the 2021/22 school year and very quickly really helped everyone (teachers and children alike) to understand how to work scientifically (see **pages 21-23**).

Tamara discovered that using the basic TfW techniques really helped the children understand the science and explain their science clearly. It linked to understanding scientific vocabulary but it also made them interested in the science because it is active and enabled them to access what they were being taught. Significantly, it dovetails with all the skills they bring from their literacy so they can transfer these key skills to science. They already know how to text map; they already know how to use actions and create a toolbox. Warren Road is part of the STEM community – science technology engineering and maths – and has found the TfW process very much enhances it. In Tamara's words:

"As science lead, I'm coming from a science perspective. So, the question is, what are we trying to do in science? I've found out that the TfW underpinning process is a very effective way of delivering science. Why? Because it's brilliant with vocabulary and it helps our SEND and the 20% lower-achieving pupils access the curriculum. Importantly, it benefits all pupils. It does this by using actions to enhance understanding of the knowledge needed so the children learn how to work scientifically. Science has a language of its own so the children have to understand the meaning of say solid, liquid and gas from a science perspective as well as terms like hypothesis. They are learning a new language – so they have to have the tune of science. Moreover, in science you have to be precise in a way that is very different from the use of language in the English curriculum. By Year 6, you need to be able to write scientifically using the core vocabulary appropriately."

Appendix 4: Science vocabulary progression (Briar Hill Primary School)

Year 1: *Spring, Summer, Autumn Winter, deciduous, evergreen, weather, clouds, forecast, droplets, Sun, Earth, star, night, day, Moon, solar-system, planet, fish, carnivore, herbivore, sight, sound, taste, hear, touch, wood, plastic, glass, metal, rock, fabric, properties, stretchy, stiff, shiny, bendy, absorbent, opaque, transparent, roots, stem, bloom, petal, seed, trunk, bark, edible, blossom, fruit, bulb, branches, suited, needs, insect, spider, bird, mammal.*

Year 2: *mature plant, temperature, reproduce, disperse, stem, leaf, petal, pollen, nutrients, living, dead, alive, insect, adaptation, survive, grow, change, Teeth, Incisor, canines, premolars, molars, exercise, healthy, requirements, balanced diet, electricity, safety, bulb, appliance, battery, mains, switch, circuit, materials, conductor/non-conductor, habitat/ micro-habitat, food chain, food source, environment, shelter, seashore, ocean, woodland, rainforest, nocturnal, adaptation, properties, classify, purpose, suitability, bending, twisting, absorbent, opaque, transparent.*

Year 3: *magnet, pole, attract, repel, compass, aluminium, iron, steel, copper, needle, lever, pulley, wheel, axle, friction, incline, gear, wedge, screw, split, ridges, wheel, ramps, clockwise/ anticlockwise, stomach, oesophagus, intestine, energy, waste, nutrition, carbohydrates, protein, dairy, fruit, vegetables, fat, sugar, cell, tissue, liver, vitamin, mineral, organs, acid, saliva, classification key, endangered, mammal, amphibian, reptile, bird, vertebrate, invertebrate, insect, thorax, abdomen, exoskeleton, pollination, stamen, anther, stigma, ovary, condensation, precipitation, evaporation, solid, liquid, gas, vapour, states of matter.*

Year 4: *skeleton, bones, joints, cartilage, ligaments, tendons, skull, pelvis, spine, ribs, scapula, marrow, x-ray, muscles, cooperation, antagonistic, voluntary/involuntary, biceps, triceps, sound, larynx, vibrations, compress, decompress, weaker, intensity, pitch, cartilage, vibrations, eardrum, anvil, solid, liquid, gas, particle, atom, changing state, vibration, universe, galaxy, planet, milky way, solar system, orbit, waxing, waning, new moon, crescent, black hole, constellation, star, asteroid, comet, meteor, bend, block, opaque, transparent, translucent, mirror, reflect, concave, convex, rays, predator, prey, consumer, omnivore.*

Year 5: *circulation, respiration, aerobic, vessel, atria, ventricles, valve, aorta, arteries, capillaries, veins, plasma, haemoglobin, platelets, pulse, fossils, sedimentary, igneous, metamorphic, organic, formation, deposited, weathering, erosion, crust, mantle, core, insulator, conductor, static, circuit, appliance, electromagnet, cell, coal, current, flow, bulb, switch, lens, light rays, refraction, binoculars, microscope, telescope, prism, cornea, pupil, iris, retina, optic nerve, adaptation, evolution, extinct, generation, genes, hereditary, mutation, offspring, organism, species, ancestor, inheritance, variation, descended.*

Year 6: *reversible/irreversible, soluble/insoluble, solution, saturated, atom, element, Periodic Table, matter, mass, pulley, gear, lever, mechanism, embryo, infant, adolescence, amphibian, mammal, chlorophyll, photosynthesis, botanist, vascular/non-vascular, germination, seed dispersal, fertilise, pollination, insect, nutrients, water, transported, puberty, exercise, drugs, lifestyle, algae, taxonomy, species, invertebrate, fish, birds, reptiles, vertebrate, organism, fungus, protist, prokaryote, bacteria, kingdom.*