York St John University

Mentor Support Booklet

Subject specific feedback & setting targets

in

SCIENCE

CONTENTS

Science Subject Knowledge

As in any area of the curriculum, good teaching is grounded in secure subject knowledge – both knowledge of the subject and pedagogic subject knowledge.

However, the main challenge for students when teaching science appears to focus on two main areas – dealing with misconceptions (the children's and their own) and scientific enquiry. Their main worries, throughout all of our programmes, usually centre on 'what do we do if the children ask us a question and we don't know the answer?'

Student teachers will benefit from feedback which focuses specifically on their subject knowledge and their thinking about how children learn in science. This booklet outlines the key messages that we give the students for science teaching as well as a range of supporting documents that we hope you will find useful when discussing science specific feedback and support.

The key messages for science are based on evidence of what works from recent research and current literature, Ofsted subject reports and national guidance. Tutors have many years teaching in a primary school and working to support primary teachers in science in a Local Authority capacity.

To develop their subject knowledge, student teachers can be referred to their session inputs and the wide range of materials available to them either in hard copy or eBooks from the University library.

Books and resources that they will find useful throughout their placement are:

Allen, M. (2010) **Misconceptions in Primary Science.** Berkshire, OUP.

DfEE (1999**) National Curriculum**. London, DfEE/QCA.

QCA (2000) **Science – A Scheme of work for Key Stages 1 and 2.** London, QCA.

Harlen, W. & Qualter, A. (2009) **The Teaching of Science in Primary Schools.** London, David Fulton Publishers.

‘Minds-on’ as well as ‘Hands-on’

Key messages for student teachers:

Children learn by ‘doing’ so practical activities are clearly important. However, they are not the complete story and there is much research which suggests that as well as ‘hands-on’ children should be ‘minds-on’ as well.

Think very carefully about what you want the children to learn and to use Wynne Harlen’s guidance which is to encourage the children to think about the ‘big ideas’ in science – where does it all fit in in the scheme of things? Making activities relevant to the lives of the children is very important.

Once the intended learning is established ***then*** think about the type of activity that is best to bring about that learning – rather than finding a brilliant activity where the learning has to be somehow fitted into it.

Related to any practical activity should be corresponding ‘thinking time’ where plans, results, relationships and consequences are considered – this is the ‘minds-on’ bit and is essential if children’s scientific thinking is to be developed. Practical activities generally lack ***scientific*** challenge although the children may well find accurate measurement and using some equipment difficult due to their inability to read scales and underdeveloped manipulative skills.

Sometimes it is useful to demonstrate activities to the children but they must consider very carefully why they need to do this:

- Is it for Health and Safety reasons? (then ask whether it is really appropriate at all);
- Is it due to lack of resources? (then think about an alternative approach);
- Is it due to the children’s poor behaviour? (then think about alternative classroom management approaches);
- Is it just to get a point across quickly and efficiently? (then this is probably a good idea).

Children often take much longer to carry out practical work than you anticipate – or if there is a carousel of activities they might finish one activity much quicker than another and congestion occurs. Backup activities are always a good idea for quick finishers and always, but always try the activity first before giving it to the children!

Always check that there is enough equipment (and that it works!) and decide carefully whether the children should be provided with the necessary items or whether they should be encouraged to choose for themselves. Whatever route they decide on they should make sure that they have anticipated, as far as possible, what the children might need.

Examples of targets for student teachers

Make sure you have checked the resources that you intend to use well before the lesson.

Decide carefully whether you should demonstrate an activity or whether the children could more usefully do it themselves.

Try to involve the children as much as possible in what to do and how to do practical work rather than planning it all yourself – this will give you very useful information about their level of scientific thinking.

Make sure you model the use of equipment and practical skills as necessary.

Make sure you allow plenty of time for the children to 'think' as well as 'do'.

Try to anticipate what the children might need or ask for and have resources ready but not necessarily out on show.

Misconceptions

Key messages for student teachers:

The way that children explain what happens in the world around them is fascinating and gives us a window into their cognitive development. Often this thinking is not scientific – particularly in young children – but by careful planning and provision we can help them to experience events that will encourage them to 'reframe' their thinking – in other words to 'resolve' their misconceptions – and begin to think more scientifically.

Children create explanations based on the evidence that they have at that time or ideas that make sense to them. An example of a misconception might be that 'light things float – heavy things sink'. Careful provision of resources will help children to experience for themselves that, in fact, some very heavy things do float. Often it is not sufficient to just 'tell' the children the answer because they more than likely will not change their mind.

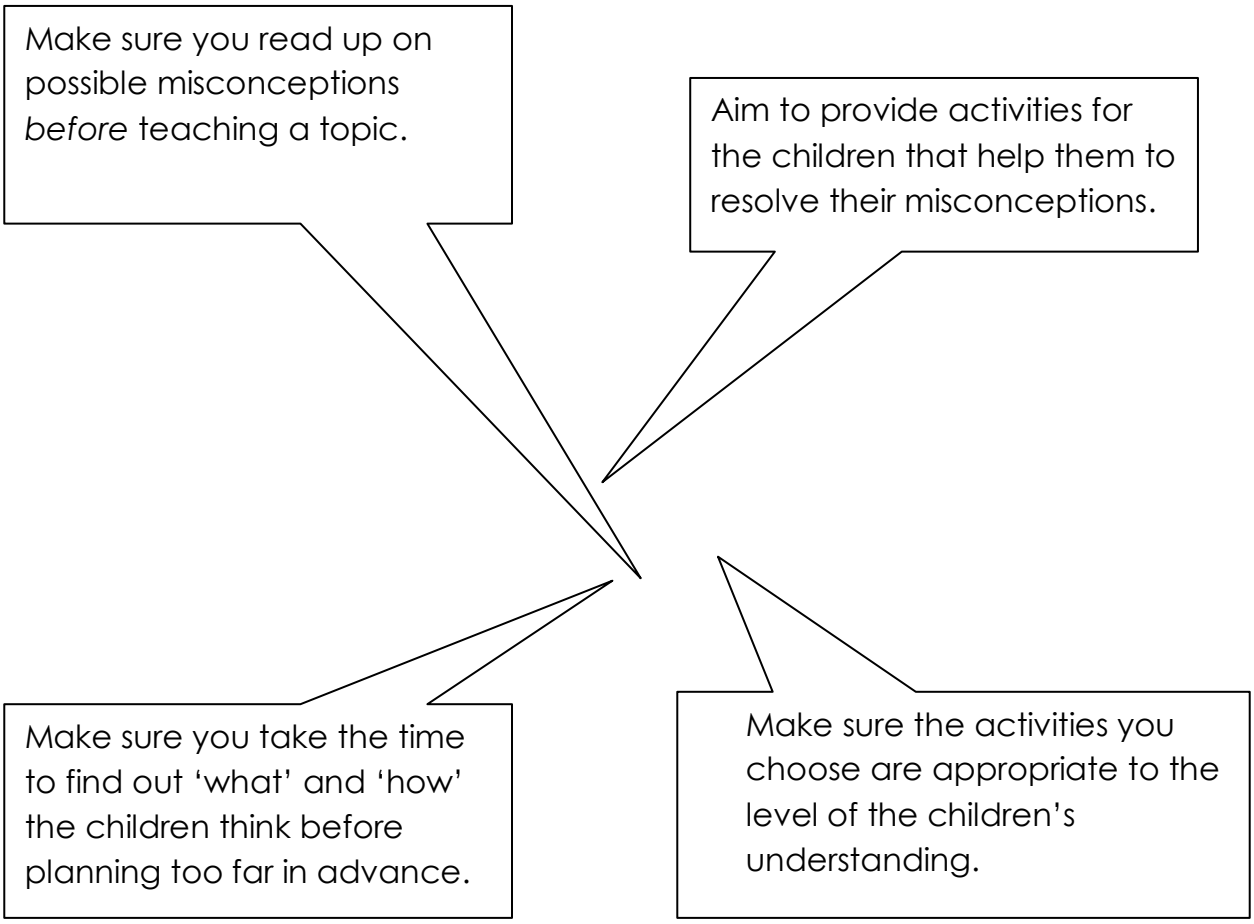
There are times, however, when it is not possible to provide for misconceptions – either because the children are not conceptually ready – Key Stage 1 children thinking the moon is a source of light, for example – or there are not the resources available. In the case of the moon, just telling them that it is not a source of light but like a 'big mirror shining the sun at us' will probably be enough. They still might not believe you but at least you have sown the seed for later.

Careful questioning and discussions with the children will help to tease out their misconceptions and give an idea about where to go with planning. Ignoring children's misconceptions at a key point in a lesson or series of lessons will more than likely result in the children missing the point and not making progress in their scientific thinking.

Avoid carrying out activities that might reinforce children's misconceptions because they require them to understand scientific 'models', for example, particle theory, flow of electrons round a circuit, electrical resistance and so on. The children will happily run around like particles in a gas but they do not have the conceptual understanding to deal with the size of the particles and the vacuum that is in between them so the point of the activity is lost.

Read up on possible misconceptions *before* starting a topic – this will give a useful starting point for questions. Michael Allen's 'Misconceptions in Primary Science' is available as an eBook on the York St John University library website.

Examples of targets for student teachers



Scientific Enquiry

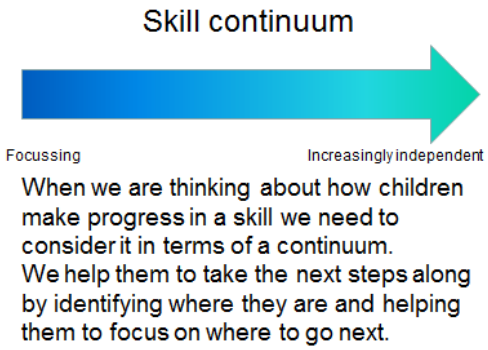
Key messages for student teachers:

Scientific enquiry skills (Sc1) underpin the rest of the science curriculum and are taught in the context of Life Processes and Living Things (Sc2), Materials and their Properties (Sc3) and Physical Processes (Sc4).

Scientific enquiry is not just about 'fair testing' and children should be given the opportunity to explore widely.

We would expect that there would be a learning objective relating to Sc1 skills development in each lesson, in addition to one for subject knowledge development. Where there is an Sc1 objective we would expect that there will be the accompanying success criteria, in the form of 'steps to success' for example, and appropriate assessments to accompany this. Sc1 assessment will often involve observations of the children working with evidence of their skills being recorded on post-it notes or photos during the activities, for example.

Sc1 skills are developed when the children carry out explorations and investigations throughout the Early Years and Key Stages 1 and 2. The skills are developed on a continuum and need to be taught (Appendix 2):



Skills like planning, observing, recording, presenting, analysing and evaluating feature within each year group but at a level that is appropriate to the stage the children are at in their thinking and experience. Appendix 2 gives examples of what the children need to be taught in each year group in order to make progress in their Sc1 skills throughout Key Stages 1 and 2.

We would not expect children, particularly those in Key Stage 1, to write out a complete investigation – particularly if this involves extensive copying of the same content. We would only expect to see the children's 'independent' work – this might be individual, pairs or group contributions.

Certain topics lend themselves to a particular Sc1 skills focus and Appendix 3 gives suggestions for what skills match which units. This is taken from the QCA scheme of work which we know is no longer widely used but which still gives a useful starting point when teaching science.

Examples of targets for student teachers

Make sure you record observations of the children's Sc1 skills whilst they are working ready to think about their progress with them during the plenary and in your evaluation of their learning at the end of the lesson.

Make sure you discuss and model the Sc1 skills – including the steps to success - before sending the children off to their activities.

Decide on just one or two Sc1 learning objectives – 'we are learning to investigate' is too broad.

Choose an appropriate Sc1 focus based on the type of investigation the children are carrying out.

Only ask the children to write up independently those aspects you intend to assess - they do not need to write out the whole investigation. Think carefully whether the children need to write anything at all – are there other ways of recording?

(They should make sure they take account of school policy on this, though).

Dealing with questions

Key messages for student teachers

Children's questions

Children are naturally inquisitive and ask **lots** of questions. In fact, that is one thing that gives us an indication of a child's ability. Curiosity is a good thing.

It is not, however, essential that adults answer all their questions immediately as if they were an encyclopaedia. Sometimes the questions are not immediately answerable because you just do not know the answer or because an answer would be beyond the child's understanding. Likewise you do not want to develop a situation where the children depend on you for the answer all the time without putting any of their own effort in. The ideal situation is where you learn and find things out together and eventually help the children to find things out for themselves – to become independent learners. "I'm not sure, I wonder how we could find out?" or "Let's write that question down on a post-it and find out the answer as we go through the topic", are possible ways of dealing with this and will help the children on the road towards independence.

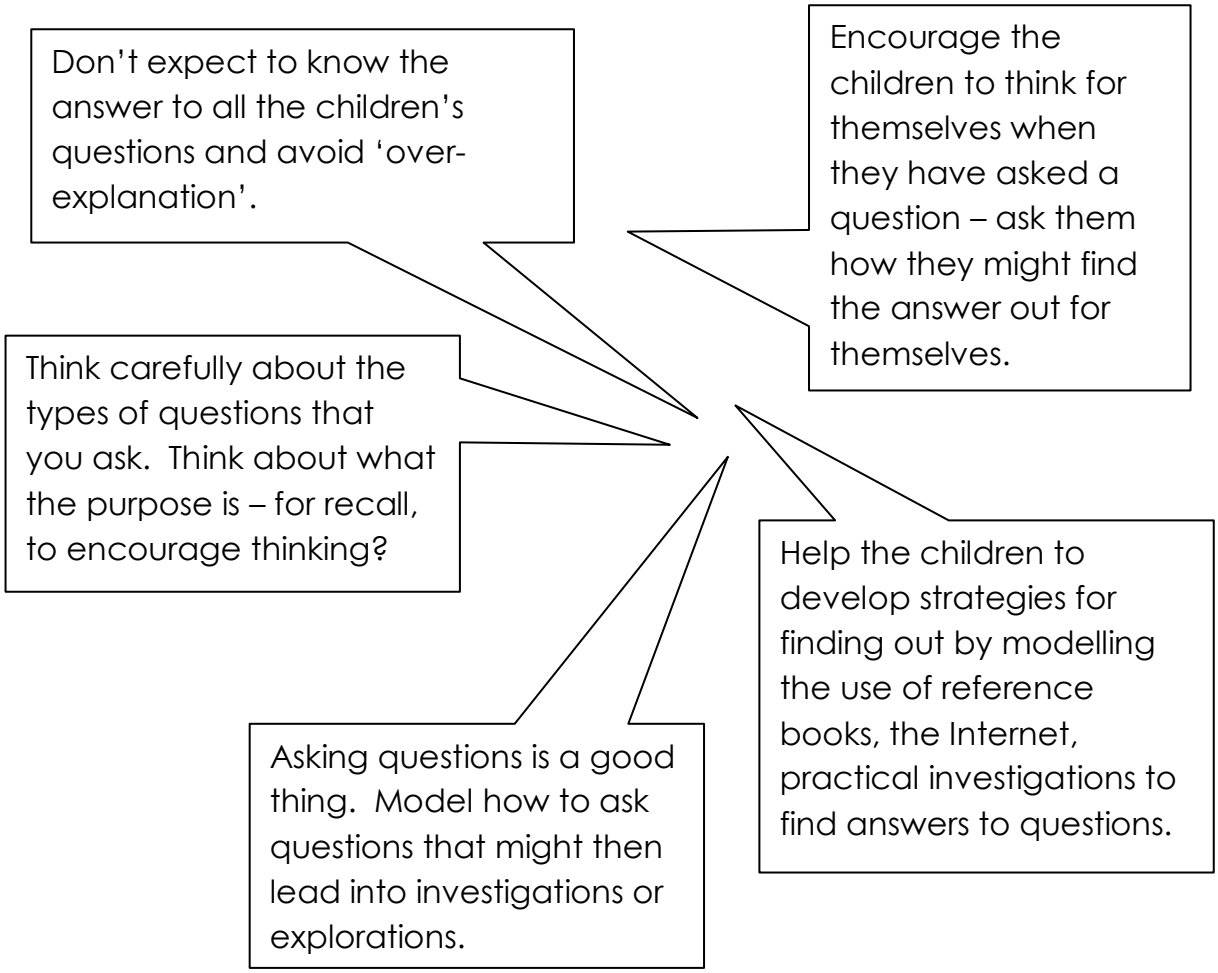
Your questions

Open questions are useful in some circumstances, particularly if you want to encourage the children to think. There are some instances when open questions are not productive, particularly with young children, and they can cause confusion and a change of subject by them. So, you need to think carefully about the purpose of your questions and try to avoid 'closing down' discussions and thinking by striving for the answer that is in your own head but also having a realistic idea about the children's ability to answer.

Some children may feel threatened by direct questions so a softer approach is to invite them to talk to their partners or in small groups. In this way, all children have the opportunity to verbalise their thinking, even if this is not to the whole class. Some children are more articulate than others but this does not necessarily mean they are better scientific thinkers, as with the more able writers – be aware of this.

Model asking questions. This is particularly useful when thinking about things to explore and investigate – "I wonder what would happen if……?" or "I wonder what we might find if……?"

Examples of targets for student teachers



"Yes, but why are my eyes brown and the hamster's eyes are red?" Rebecca (Age 4)

"Why isn't salt sweet like sugar – it looks the same!" Jacob (Age 5)

"If we dug a *really* deep hole will we reach through to the other side of the Earth?" Thomas (Age 9)

Vocabulary

Key messages for student teachers:

Subject specific vocabulary is often what sets scientific talk apart from our everyday conversations. This can also cause great confusion and lead to misconceptions not being identified or addressed. 'Material' is a good example of this – material is 'fabric' in everyday language but 'matter' in scientific terms but then 'matter' means other things too!

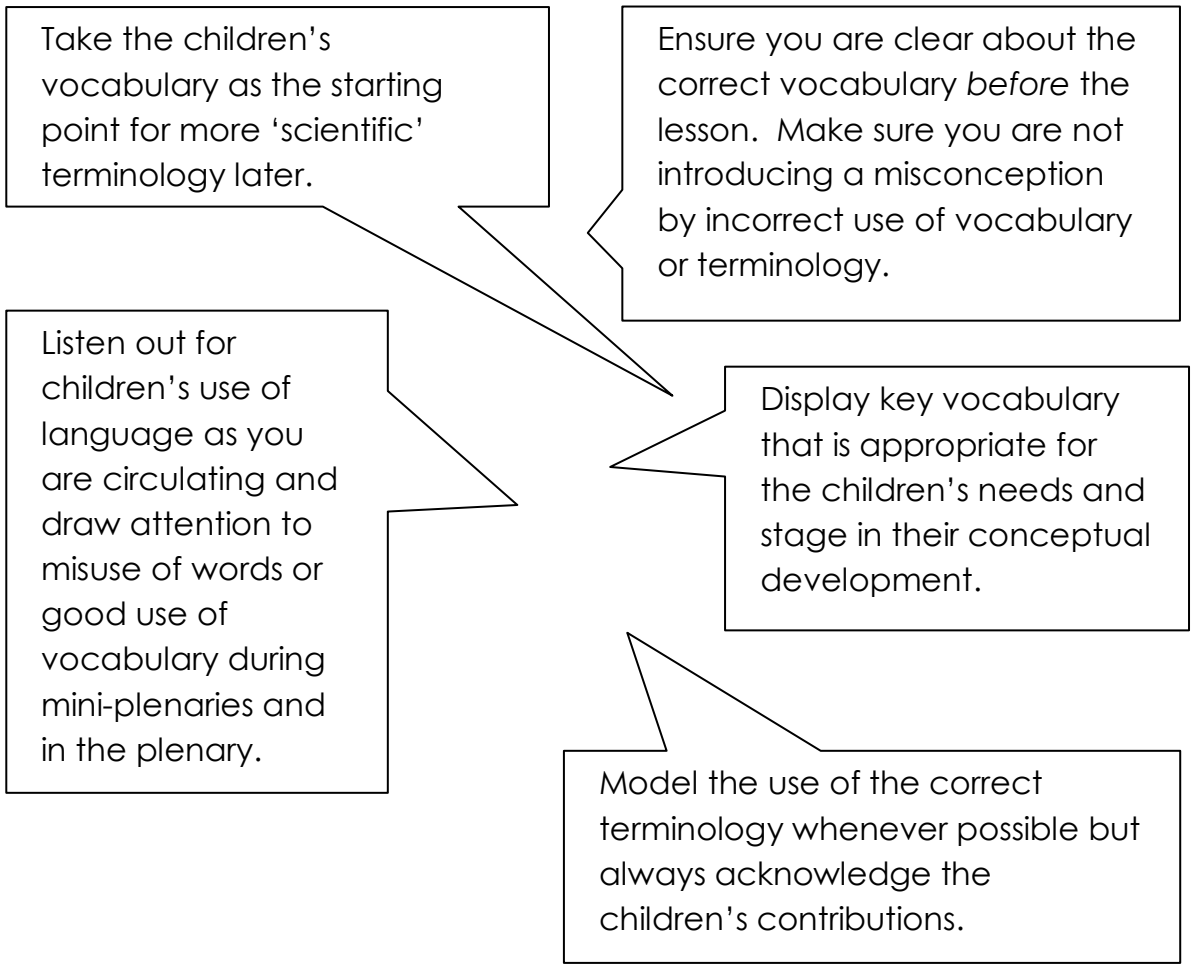
Children will have their own terminology and vocabulary to describe objects and events and this should be respected and acknowledged. When the children have reached a stage where, in order to properly differentiate between things they need specific vocabulary, then this is when it should be introduced. So, in order to choose the correct piece of equipment they need to know that it is called a 'measuring cylinder' then it is appropriate to call it that.

Be careful not to use an over-complicated word when a simpler one is perfectly acceptable – 'stretchy' is a good word to describe the rubber that a balloon is made from.

Display the words that the children are likely to need and encourage them to use them in their discussions. You need to model this and use age-appropriate vocabulary – check the QCA scheme of work for science to help you gauge the appropriate language within topic areas.

Use children's discussions in pairs and groups to give an insight into their developing vocabulary and try to match this but begin introducing more scientific terminology, as appropriate.

Examples of targets for student teachers



Appendix

Appendix 1 – planning for science

Appendix 2 – teaching objectives for Sc1

Appendix 3 – Scientific enquiry skills and topic focus

Appendix 1 - Things to think about when planning a science lesson

Stage 1: Planning for the learning

What scientific knowledge and understanding do you want the children to develop in this lesson?
How does it fit into their overall progression and prior knowledge in this topic?
What misconceptions might they have?

What scientific enquiry skill(s) do you want them to learn or develop further?
How does this fit into their overall progression in this skill?

What activities will be the most suitable for helping the children to gain this knowledge or develop these skills?
Will the activities help to give you useful assessment information?
Are they safe/appropriate?
Will they help to address the children's misconceptions?

Make sure you try out the activities first and check that there is enough equipment and that it is working.

Stage 2: Planning the detail

Start of the lesson:

Eliciting the children's ideas – How will you find out what they already know? How will you find out what they want to learn about?

Talking about the learning and how to achieve it:

Learning objectives (LO):	What are they learning to do? How does this relate to what they already know or what they can already do?
Success criteria (SC):	What are the steps to achieving the learning? How will they show the learning outcomes?
Assessment:	What types of evidence will you be looking for during the lesson and afterwards - what will this show you? This should relate to your LO and SC.

Activities:

What will you need to model?

What vocabulary will you be introducing/expecting the children to use? How will you support the children with this?

What resources will you/they need? How will you organise these and will it encourage the children's increasing independence in practical work?

What information do they need? What results/observations will they be collecting? How will they get this information? Do they need a period of exploration first?

What groupings will the children be in throughout the lesson – paired work/small groups/whole class?

Will the children be in like ability or mixed ability groups? Think about why you have chosen this approach.

What support might they need – adult support/writing frames/work buddy?

What context will you set the activities in to make sure the experience is meaningful and relevant to the children?

What cross-curricular skills do you want them to use or develop?

Mini-plenaries and plenary:

Throughout the lesson you should think about the key questions that you will ask the children.

How will you review how they are getting on during the lesson?

How will you encourage them to talk about what they have been doing, what do you want them to think about?

How will they analyse their methods/results?

How will they review their learning during and at the end of the lesson?
(Make sure you consider the learning objectives and reflect on what they needed to do to be successful).

Stage 3: Reviewing the learning, assessment of learning and feeding forward:

How will this inform where you go next?

Appendix 2 - Teaching Objectives for Scientific Enquiry

Emphasis could be placed on **teaching** the following skills:

KS1	Planning	Carrying Out	Analysing	Evaluating
Year 1	Show them how to test ideas suggested to them Explain how to say what they think will happen Encourage them to start thinking for themselves about how they could test their ideas for experiments	Show them how to make sensible observations Show them how to measure length using non-standard and then standard measures Teach them how to complete results tables	Encourage them to explain their observations and then draw, label and write about them simply Explain how to make comparisons and say what their observations show Teach them how to draw block graphs Explain how to draw simple conclusions from their results Begin encouraging them to link what they said they thought would happen with what did happen	Not expected in Year 1 although some simple evaluations might be useful to model
Year 2	Encourage children to think of some of their own ideas for experiments and to suggest how they might test them Encourage them to say what they think might happen Explain about the idea of fair testing and discuss what this means	Encourage them to measure length using non-standard and then standard measures Demonstrate how to measure volume, time whenever possible Encourage them to record their observations – using appropriate writing frames to structure this	Encourage them to make simple comparisons between things they have observed Encourage them to present findings in block graphs and teach them how to interpret what they show Encourage them to link their predictions with what they found out Begin encouraging them to offer explanations for what they found out and begin drawing conclusions	Not expected in Year 2 although some simple evaluations might be useful to model

Teaching Objectives for Scientific Enquiry

Emphasis could be placed on **teaching** the following skills:

KS2	Planning	Carrying Out	Analysing	Evaluating
Year 3	Encourage them to think more independently about ideas and how to test them Encourage them to say what they think might happen and begin helping them to use more scientific ideas and vocabulary Encourage them to think about fair testing. Help them to plan their ideas for experiments in a fair way	Encourage them to think in more detail about observations they could make Encourage them to use measuring equipment with increasing accuracy eg when measuring length, volume and time	Expect results to be presented in labelled drawings, bar charts and tables. Provide appropriate writing frames/support to facilitate this Encourage and help them to use scientific knowledge when explaining what they found out Encourage and help them to generalise about what has happened and to identify and interpret patterns in results	Encourage them to think about whether they have enough evidence Encourage them to think about whether their test was really fair
Year 4	Expect them to suggest questions to test and make predictions Encourage and help them to think in terms of scientific knowledge Expect them to plan with a fair test in mind Encourage them to choose equipment and decide what to measure	Encourage them to make a range of relevant observations and record them appropriately Show them how to measure temperature, time and force with appropriate accuracy	Expect results to be presented in bar charts and tables Encourage them to link patterns in graphs, bar charts and tables with their explanations for what has happened Encourage them to think about whether they have enough evidence to support their initial idea Encourage them to use scientific knowledge and understanding	Explain and demonstrate why some measurements should be repeated eg length in order to increase reliability

Teaching Objectives for Scientific Enquiry

Emphasis could be placed on **teaching** the following skills:

KS2	Planning	Carrying Out	Analysing	Evaluating
Year 5	Expect them to suggest questions to test and make predictions in terms of their scientific knowledge and understanding Expect them to plan for a fair test and appreciate how much evidence they will need to collect Encourage them to identify all the factors that they will need to take into account when planning an experiment eg time factors, costs, equipment available etc	Expect them to make relevant observations and measurements of appropriate accuracy	Teach them how to present appropriate results as line graphs Encourage them to decide whether their results support their original prediction and link this to their charts and graphs Encourage them to make additional predictions based on patterns in their data Draw conclusions about their findings	Help and encourage them to think about why many observations and measurements should be repeated
Year 6	Encourage them to decide how to turn ideas into a form that can be tested Expect them to make predictions based on scientific knowledge and understanding identifying relevant factors Expect them to decide what evidence they need to collect, how much they evidence they need and the equipment they need to use	Expect them to use a range of equipment correctly and with appropriate accuracy Expect them to present their results in the most appropriate way Encourage them to consider safety issues	Expect them to make comparisons using tables, bar charts and line graphs Encourage them to use their results to make further predictions and suggest explanations using scientific knowledge and understanding Encourage them to say whether their evidence supports their original prediction	Encourage them to decide when observations and measurements need to be repeated to give more reliable data Encourage them to identify results that do not seem to fit the pattern

Appendix 3 - Examples of skill areas in Scientific Enquiry

Green – Planning and Predicting; Pink – Carrying out, Observing and recording; Blue – Analysing results and making conclusions

YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6
1A Ourselves Making and communicating observations	**2A Health and Growth** Present information in charts, tables and interpret	**3A Teeth and Eating** Is there enough evidence?	**4A Moving and Growing** Interpreting evidence	**5A Keeping Healthy** Repeating measurements Presenting line graphs and linking this to the original idea	**6A Interdependence and Adaptation** Measuring and observing carefully Explain findings scientifically
1B Growing Plants Turning ideas into a form that can be tested	**2B Plants and Animals** Encourage explanations and draw conclusions	**3B Helping Plants Grow Well** Measuring length accurately	**4B Habitats** Explain findings using scientific knowledge and understanding	**5B Life Cycles** Drawing conclusions	**6B Micro-organisms** Deciding if the evidence supports the original idea
1C Sorting and using materials About saying what they expect to happen Deciding whether what they expected to happen did	**2C Variation** Record observations	**3C Characteristics of Materials** Planning investigations-what to change, what to measure	**4C Keeping Warm** Measure temperature and time with appropriate accuracy Identify and link patterns with explanations	**5C Gases Around Us** Repeating measurements	**6C More Dissolving** Deciding which observations should be repeated and why
1D Light and Dark Explain how to make comparisons and say what their observations show	**2D Grouping and Changing Materials** Predicting, fair testing Link predictions to findings	**3D Rocks and Soils** Measuring volume accurately	**4D Solids and Liquids** Making and recording observations, choosing equipment	**5D Changing State** Make additional predictions based on patterns in data Measure with appropriate accuracy	**6D Reversible and Irreversible Changes** Safety issues Careful observations
1E Pushes and Pulls Measure length using standard or non-standard measures How to complete results tables	**2E Forces and Movement** Measuring length and time	**3E Magnets and Springs** Predicting and looking for patterns in results	**4E Friction** Explain and demonstrate repeats to increase reliability	**5E Earth, Sun and Moon** Presenting data in graphs	**6E Forces in Action** Interpreting patterns and identifying anomalous results
1F Sound and Hearing How to draw a block graph	**2F Using Electricity** Observations and comparisons	**3F Light and Shadows** Use scientific knowledge to explain findings. Reminder for ways of recording	**4F Circuits and Conductors** Plan in terms of scientific ideas. Use results to draw conclusions	**5F Changing Sounds** Identify relevant factors to take into account	**6F Seeing Things** To consider trends in results and to decide which results do not fit the pattern
					6G Changing Circuits To suggest a question to investigate