Key Stage 3 National Pilot

Science

Unit 15

Numeracy in Key Stage 3 Science
Notes for consultants and tutors

Organisation of this pack

This pack contains the materials, background notes and guidance for Unit 15, Numeracy in Key Stage 3 Science. As the Key Stage 3 science consultant or tutor, you will use them as part of the Key Stage 3 National Pilot for Science.

Evaluation sheets

At the beginning of each unit you should give out the evaluation sheet. This can be found on page 3. Time is provided at the end of sessions 1 — 5 for participants to reflect on the objectives of each session and evaluate the session. Collect the completed sheets at the end of the unit. You will need to read them and to summarise the data. This will be collected as part of the Key Stage 3 National Pilot.

As well as an evaluation sheet for participants, there is also one included for you, as the tutor. Please complete this after completion of the unit and your analysis of the participant evaluation sheets. Please return to Adam Phelps, at the National Centre, 59-65 London Street, Reading RG1 4EW.

Before attending this unit

Teachers may have attended a ‘Numeracy across the curriculum’ training session. It will be useful for you to check the arrangements in your own LEA so that you will have some idea of the number of participants who have attended this training.

Writing to schools before this unit

You will need to prepare and send to schools a programme based on the outline of the unit, tailoring times of sessions to suit local circumstances.

You may also want to prepare and send a list of participants’ names and their schools to those who are attending, together with a map of how to travel to the venue. You also need to include details of the pre-unit task.

You should ask participants to bring with them the following materials:

Notes from the pre-unit task
A copy of the QCA/DfEE exemplar Scheme of Work.
Key Stage 3 National Pilot Science

FOR COMPLETION BY TEACHERS  Evaluation: Unit 15

What were the most successful aspects of today's sessions?

What changes would you suggest if today's sessions were repeated?

Please grade each session on the basis of how useful it was for you.

<table>
<thead>
<tr>
<th>Session</th>
<th>Grade: please ring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 = very good 4 = poor</td>
</tr>
<tr>
<td>Pre-unit task</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Session 1</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Session 2</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Session 3</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Session 4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Session 5</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Session 6</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>

Overall grade for the unit 1 2 3 4

School ................................ Post held ......................................

Please return this form to your tutor before leaving.
Key Stage 3 National Pilot Science

FOR COMPLETION BY CONSULTANTS OR TUTORS AFTER UNIT 15

LEA: ..............................................................

What were the most successful aspects of today's sessions?

What changes do you suggest might be made to improve this unit:

a. From the tutor's point of view?

b. From the participants' point of view?
Key Stage 3 National Pilot: Science

Please grade the tutor's material 1 to 4 for clarity, level of support, ease of use, and so on.

<table>
<thead>
<tr>
<th>Session</th>
<th>Grade: please ring</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-unit task</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>Session 2</td>
<td>1 2 3 4</td>
<td></td>
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<td>Session 3</td>
<td>1 2 3 4</td>
<td></td>
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<tr>
<td>Session 4</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>Session 5</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>Session 6</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>Overall grade</td>
<td>1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>
Please collate the grades given to each session by the teachers attending. Please provide numbers, not percentages.

<table>
<thead>
<tr>
<th>Session</th>
<th>Number for each grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3  4  No grade</td>
</tr>
</tbody>
</table>

Pre-unit information

Session 1

Session 2

Session 3

Session 4

Session 5

Session 6

Overall grade

Please return this form to Adam Phelps at the National Centre, 59-65 London Street, Reading RG1 4EW.
Focus of unit

The standards for science teachers on which this training is based have been made available to all pilot LEAs. Unit 15, Numeracy in Key Stage 3 Science, aims to address those standards reproduced below. They are in the form and order in which they appear in the original document, although this is not necessarily the order in which they are addressed in the unit. Where the unit addresses only part of a standard, italics are used to show those parts which are not included. The draft standards will be evaluated during the pilot.

SUBJECT KNOWLEDGE AND UNDERSTANDING

In order to secure high standards in pupils' learning, teachers should:

- have sufficient knowledge and understanding of all areas included in the National Curriculum for science at Key Stage 3 so that they can teach the whole programme of study with confidence
- understand a range of ways of investigating scientific questions so that they can choose ways of developing pupils' competence in investigation
- have strategies for engaging all pupils in science and maintaining pupil motivation.

PEDAGOGICAL KNOWLEDGE

In order to secure high standards in pupils' learning, teachers should routinely evaluate approaches used. They should:

- set realistic but challenging learning objectives for all pupils, building on prior learning so that expectations are high
- identify appropriate teaching methods, including whole-class, group and individual approaches, and use these effectively, making the best use of available teaching time and ensuring previous learning is recalled and new learning reviewed
- use a wide range of activities well matched to the learning to be achieved
- frame and adjust questions for different purposes including:
  - probing understanding and the development of understanding
  - identifying misunderstandings
  - making connections across areas of science
  - stimulating discussion, including discussion of sensitive and controversial issues
  - stimulating speculation, logical reasoning and the ability to develop arguments
- provide exposition designed to promote pupils’ understanding, encouraging pupils to talk about their ideas and communicate their understanding
- have strategies for teaching numeracy skills in a scientific context and for developing pupils’ mathematical competence.

PROGRESSION FROM KEY STAGE 2 AND ACROSS KEY STAGE

In order to secure high standards in pupils’ learning, teachers should:

- have a secure understanding of teaching and learning in science at Key Stage 2 including the types of activity used so that they can build on this at Key Stage 3 avoiding obvious discontinuities and develop pupils’ understanding by using different approaches or contexts for presenting key ideas
- have a clear understanding of the areas of Key Stage 3 science where pupils’ knowledge and understanding are likely to be good and where knowledge and understanding are likely to be less secure so that they can focus teaching appropriately
- have ways of adapting learning objectives and activities for pupils of differing attainment and/or prior learning and of recognising evidence of progression in different pupils
- know about common strengths and weaknesses in pupils’ numeracy and literacy at the end of Key Stage 2 and during Key Stage 3 so that they can relate these to work in science
- identify and understand how science can benefit from, and contribute to, improvements in literacy and numeracy at Key Stage 3.

Overview Unit 15

Objectives for the unit

- To develop participants’ understanding of the part that mathematics plays in raising standards in science
- To provide a range of strategies to help participants to develop pupils’ understanding of number work in the context of science
- To provide a range of strategies to help participants to develop pupils’ graph work in the context of science
- To provide participants with techniques for developing pupils’ understanding of magnification
- To provide participants with the opportunity to develop numeracy starter activities for science lessons
Outline

Pre-unit task

Session 1  Cross-curricular priorities  45 minutes
Session 2  Calculation and number work  30 minutes
Session 3  Scales and graphs  40 minutes
Session 4  Magnification  10 minutes
Session 5  Starter activities  25 minutes
Session 6  Plenary and introduction to follow-up work  10 minutes

Time has been allowed for a refreshment break.

Synopsis

The unit is intended to provide participants with the opportunity to reflect on some of the issues relating to the relationship between pupils’ abilities in mathematics and their progress in science. It provides some strategies to enable participants to support and develop pupils’ mathematical abilities particularly in terms of the application to science.

Pre-unit task
Participants are asked to reflect on where pupils’ mathematical skills enhance and hinder progress in science in their current Key Stage 3 scheme of work. The notes they make will be used during the training.

Session 1
In this session participants will consider the outcomes from the pre-unit task. They will be made familiar with the cross-curricular priorities as identified in the ‘Numeracy across the curriculum’ training and will match these to the QCA/DfEE Scheme of Work.

Session 2
In this session participants will be made familiar with number lines and how they can be used. They will also consider different strategies that are used for calculating. Issues relating to the use of calculators will be covered.

Session 3
Work done in session 2 on number lines will be extended to their use in supporting pupils to develop their abilities to read scales. Participants will then be given strategies for helping pupils to select scales for graphs and to interpret graphs.
Session 4
This session provides participants with strategies for supporting pupils in their understanding of magnification and the relative sizes of objects when seen under a microscope.

Session 5
This session will explain how mathematical starter activities can be used in science lessons. It will enable participants to appreciate the characteristics of starter activities. Using information from earlier sessions, participants will develop different starter activities they can use in their lessons.

Session 6
Tutors will describe the post-unit tasks participants can choose to do or negotiate individual tasks. The evaluation form is completed.

Timing and materials
For this three-hour unit all OHTs are handouts and are numbered sequentially.

Tutors will need:

<table>
<thead>
<tr>
<th>Session</th>
<th>Time (mins)</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-unit task</td>
<td></td>
<td>Proforma for completing pre-unit task</td>
</tr>
<tr>
<td>Session 1 Cross-curricular priorities</td>
<td>45</td>
<td>OHTs 1,2,3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Handouts 4,5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National Curriculum Order for Science</td>
</tr>
<tr>
<td></td>
<td></td>
<td>QCA/DfEE exemplar Scheme of Work</td>
</tr>
<tr>
<td>Session 2 Calculation and number work</td>
<td>30</td>
<td>Selection of calculators (optional)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OHTs 1,6,7,8,10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Handouts 9,11</td>
</tr>
<tr>
<td>Session 3 Scales and graphs</td>
<td>40</td>
<td>Graph paper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plain paper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OHTs 1,12,13,14,17,18,19,21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Handouts 15,16,20</td>
</tr>
<tr>
<td>Session 4 Magnification</td>
<td>10</td>
<td>100 square grid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OHT 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Handout 22</td>
</tr>
</tbody>
</table>
Key Stage 3 National Pilot: Science

| Session 5 | 25 | OHT 1, 23  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Starter activities</td>
<td></td>
<td>Handout 24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 6</th>
<th>10</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plenary and introduction to follow-up work</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes for tutors**

Before preparing and delivering this unit you will need to familiarise yourself with the relevant sections of the following numeracy/mathematics documents:

- Numeracy across the curriculum
- The National Numeracy Strategy: Framework for teaching mathematics from Reception to Year 6
- Key Stage 3 National Strategy: Framework for teaching mathematics: Years 7, 8 and 9

It would also be an advantage to talk with your local numeracy/mathematics consultants, perhaps attend some relevant training they are delivering and, if possible, ask them to help you with the preparation and/or delivery of this unit.

**Participants will need to bring:**

Notes from the pre-unit task
QCA/DfEE exemplar Scheme of Work

**Pre-unit task**

The level of mathematical proficiency that pupils have, impacts on their performance in science.

Reflect on the science currently taught in Year 7 in your school. For a topic/unit from each of Sc1, 2, 3 and 4, identify a numeracy skill that pupils need and decide how their proficiency in this can hinder or enhance their progress in science.

Complete a proforma for each topic/unit completed.

You will need to bring the completed notes to the training. They will be used in the first session.
Notes for tutors

You will need to make sure that participants appreciate that they need to complete a proforma for each of Sc1, 2, 3 and 4. Sending four copies to each participant should help.

Proforma for pre-unit task

Science topic/unit:

Numeracy skill needed:

Effect on pupils’ ability to make progress in science:

Session 1

Cross-curricular priorities

Objective

- To develop participants’ understanding of the part that mathematics plays in raising standards in science

Timing

<table>
<thead>
<tr>
<th></th>
<th>1.1</th>
<th>1.2</th>
<th>1.3</th>
<th>1.4</th>
<th>45 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Introduction</td>
<td>How mathematical abilities can affect progress in science</td>
<td>Cross-curricular priorities</td>
<td>Plenary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 minutes</td>
<td>15 minutes</td>
<td>25 minutes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Draft
1.1 Introduction

Welcome the participants to the session and deal with any administrative matters.

Refer to the evaluation form. Explain that there are six sessions and five will require evaluating at the end of each session. There will be a brief plenary at the end of sessions 1-5 to enable this to take place. In addition, time will be provided in session 6 for an overall evaluation of the unit. At the end of each of the sessions use the session objectives to summarise outcomes. At this point participants should be asked to complete their evaluations for that session.

Use OHT1 to explain the objectives for the unit.

OHT 1

Objectives for the unit

- To develop participants’ understanding of the part that mathematics plays in raising standards in science
- To provide a range of strategies to help participants to develop pupils’ understanding of number work in the context of science
- To provide a range of strategies to help participants to develop pupils’ graph work in the context of science
- To provide participants with techniques for developing pupils’ understanding of magnification
- To provide participants with the opportunity to develop numeracy starter activities for science lessons

Use OHT 2 to outline the overview of the half-day and how the sessions link to the objectives.

OHT2

Numeracy in Key Stage 3 Science

Session 1  Cross-curricular priorities
Session 2  Calculation and number work
Session 3  Scales and graphs
Session 4  Magnification
Session 5  Starter activities
Session 6  Plenary and introduction to follow-up work
Say that

Some of the links between science and mathematics are identified in the National Curriculum for science. Draw participants’ attention to the references in the gutters of the Science Order – p28 2e, 2g, 2i; p29 2j–2o; p34 2a, 2f, 2g. These are summarised in Appendix 1 which you may choose to copy for participants.

Pupils’ capabilities in mathematics can affect how easily they can complete some science tasks and can, in some cases, hinder the progress they can make in science.

Notes for tutors

Make sure you are familiar with the links in the science orders referred to.

1.2 How mathematical abilities can affect progress in science

15 minutes

Task A

In groups, ask participants to share the outcomes of the pre-unit task.

Summarise findings from groups using a flipchart or overhead transparencies.

Say that

The National Numeracy Strategy (NNS) is having an effect on the mathematical ability of the pupils entering Year 7 and reference will be made in the unit to the objectives in terms of pupils’ mathematical abilities at the end of Year 6 and throughout Key Stage 3, at the end of this session.

The unit will give participants some strategies to use to assist pupils in overcoming some of the difficulties they have with numeracy without spending time teaching mathematics.

1.3 Cross-curricular priorities

25 minutes

Say that

In the ‘Numeracy across the curriculum’ training some cross-curricular priorities were identified.

Use OHT 3 and the more detailed information in Handout 4 relating to science to explain what these are.
OHT 3
Cross-curricular numeracy priorities
To improve accuracy, particularly in calculation, measurement and graphical work
To improve interpretation and presentation of graphs, charts and diagrams
To improve reasoning and problem solving

The aspects of these priorities which have the most relevance for science are listed.

Handout 4

Accuracy
- Have a sense of the size of a number and where it fits into the number system.
- Calculate accurately and efficiently.
- Calculate using fractions, decimals and percentages and use proportional reasoning.
- Use calculators appropriately and effectively.
- Use simple formulae and substitute numbers in them.
- Measure and estimate, choosing suitable units; read numbers correctly from meters, dials and scales.
- Understand and use measures of time and speed.

Interpretation and presentation of graphs, charts and diagrams
- Collect data and draw, interpret and predict from graphs, charts and diagrams and tables.
- Have some understanding of the measurement of probability and risk.

Reasoning and problem solving
- Judge reasonableness of solutions and check them when necessary.

Notes for tutors

Most of the participants will have experienced the ‘Numeracy across the curriculum’ training in their schools and may be familiar with these priorities. Try to determine the proportion and level of familiarity with the materials before you begin the session. This will affect the organisation and level of explanation you need in the initial section.
**Task B**

Allow 15 minutes for task B.

Use units from the QCA/DfEE exemplar Scheme of Work to identify links with the cross-curricular priorities.

Participants feed back to the rest of the group identifying one or two points from each unit. Use these to produce general conclusions about the needs in science for pupils to have reasonable numeracy capabilities.

Give out Handout 5.

Refer to the outcomes from the pre-unit task. Lead a brief discussion on the expectations of the mathematical capabilities of the majority of pupils when they enter Year 7 and the reality in the participants' schools.
Handout 5

Key objectives for Year 6

- Multiply and divide decimals mentally by 10 or 100, and integers by 1000, and explain the effect.
- Order a mixed set of numbers with up to three decimal places.
- Reduce a fraction to its simplest form by cancelling common factors.
- Use a fraction as an operator to find fractions of numbers or quantities (e.g. $\frac{5}{6}$ of 32, $\frac{7}{10}$ of 40, $\frac{9}{100}$ of 400 centimetres).
- Understand percentage as the number of parts in every 100, and find simple percentages of small whole number quantities.
- Solve simple problems involving ratio and proportion.
- Carry out column addition and subtraction of numbers involving decimals.
- Derive quickly division facts corresponding to multiplication tables up to 10 x 10.
- Carry out short multiplication and division of numbers involving decimals.
- Carry out long multiplication of a three-digit by a two-digit integer.
- Use a protractor to measure acute and obtuse angles to the nearest degree.
- Calculate the perimeter and area of simple compound shapes that can be split into rectangles.
- Read and plot coordinates in all four quadrants.

Notes for tutors

How you organise the groups and feedback will depend on the number of participants.

You might need to give only a sample of units if the number of participants is small, or you might divide the group into Sc1, Sc2, 3 and 4 sub-groups.

Concentrate initially on Year 7. This will enable you, if necessary, to draw participants’ attention to the key objectives for Year 6 (Handout 5) and the expectations they should have of pupils.

1.4 Plenary

Show participants OHT1 and ask them to consider whether they have a better understanding of the first objective. Invite them to complete the evaluation sheet.
Session 2

Calculation and number work

Objective
- To provide a range of strategies to help participants to develop pupils’ understanding of number work in the context of science

Timing

<table>
<thead>
<tr>
<th>2.1 The number line</th>
<th>10 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2 Calculations</td>
<td>10 minutes</td>
</tr>
<tr>
<td>2.3 Calculators</td>
<td>10 minutes</td>
</tr>
<tr>
<td>2.4 Plenary</td>
<td>10 minutes</td>
</tr>
</tbody>
</table>

2.1 The number line

Say that

Number lines are used in primary schools to help pupils develop an understanding of number and support strategies for calculating. They can be produced in a variety of forms depending on their intended use.

Use OHT 6 to show different number lines of differing complexity.

![OHT 6 Number lines](image-url)
Show how pupils can use these to support addition or subtraction of numbers, to count on forwards and backwards in different value intervals, to demonstrate equivalence, identify and estimate decimal fractions or to order numbers including negative numbers.

Use OHT 7 to demonstrate how number lines can be used to estimate decimal fractions.

**OHT 7**

What numbers go in the boxes?

3.5 lies halfway between two other numbers. What would they be?
Use OHT 8 to demonstrate how number lines can be used to help pupils to identify equivalence of fractions, decimals and percentages.

Remind participants that the expectations of the NNS are that by the age of 11 pupils will know basic addition and subtraction facts (along with multiplication tables and associated division facts). Refer back to Handout 4.

Pupils will have been encouraged to use jottings to help them in mental calculations and these could include the use of an ‘empty number line’.

Demonstrate the following calculations, using a blank OHT or a flipchart.
**Partition**

\[ 426 + 65 \]
\[ 426 + 60 = 486 \]
\[ 486 + 5 = 491 \]

**Compensation**

\[ 4.7 + 2.9 \]
\[ 4.7 + 3.0 = 7.7 \]
\[ 7.7 - 0.1 = 7.6 \]
2.2 Calculations

Task C

Give participants four calculations to perform mentally and without the use of a calculator.

Calculations

Read these out one at a time.

286 + 357
872 – 413
72 x 23

Work out the density of a material if a 25g block has a volume of 10cm³

After each question check answers (ask for volunteers or use one of the strategies from the starters session) and ask each person to explain the strategy they used to calculate the answer.

Hopefully you will have a range of strategies that has been used.
Say that

Although pupils are encouraged to learn and use efficient written methods they will be using a variety of methods in Year 7.

Give out Handout 9 and use to show the objectives for Years 7 — 9 in the Key Stage 3 Strategy for mathematics.

In mathematics, pupils in Years 8 and 9 should be able to substitute into formulae. If participants have already identified some in session 1, refer to these. If not, point out that V=I/R, D=M/V and P=F/A are the main formulae in Key Stage 3 that pupils are required to use. In science it is important that pupils also understand the relationships of the components of a formula and the science behind the statement, and do not merely carry out a mechanical exercise. Pupils also need to understand proportionality.

Draw participants' attention to objectives in different years and how they might relate to science. Use examples where possible that participants have already identified as being an issue.
### Handout 9

**Key Stage 3 mathematics**  
Selected objectives for number and calculations

<table>
<thead>
<tr>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand and use decimal notation and place value. Read and write any number from 0.001 to 1000000</td>
<td>Read and write positive integer powers of 10</td>
<td>Extend knowledge of integer powers 10. Relate to commonly used units e.g. (10^6) giga, (10^2) centi</td>
</tr>
<tr>
<td>Multiply and divide numbers by 10, 100, 1000</td>
<td>Multiply and divide numbers by 0.1 and 0.01</td>
<td>Multiply by any integer power of 10</td>
</tr>
<tr>
<td>Round positive whole numbers to the nearest 10, 100, 1000</td>
<td>Round positive whole numbers to a given power of 10</td>
<td>Use rounding to make estimates</td>
</tr>
<tr>
<td>Round positive whole numbers and decimals. Round decimals to the nearest whole number or to 1dp</td>
<td>Round decimals to the nearest whole number or to 1 or 2 dp</td>
<td>Round decimals to the nearest whole number or to 1, 2, or 3 dp</td>
</tr>
<tr>
<td>Recognise the equivalence of fractions, decimals and percentages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand addition, subtraction, multiplication and division as they apply to whole numbers and decimals</td>
<td>Understand the operation of addition, subtraction, multiplication and division as they apply to positive and negative numbers</td>
<td>Understand the effect of multiplying and dividing by numbers between 0 and 1</td>
</tr>
<tr>
<td>Use standard metric units</td>
<td>Use standard metric units extended to units of volume</td>
<td>Use compound measures e.g. speed, density</td>
</tr>
<tr>
<td>Estimate and measure</td>
<td>Extend to include volume (and bearings)</td>
<td></td>
</tr>
<tr>
<td>Recognise the equivalence of fractions, decimals and percentages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculate percentages of numbers, quantities and measurements. Use a calculator without the % key to work out percentages of numbers and measures.</td>
<td>Find the outcome of a given percentage increase or decrease</td>
<td>Use percentage changes to solve problems</td>
</tr>
<tr>
<td></td>
<td>Explain the meaning of and substitute numbers into formulae. In simple cases find an unknown where it is not the subject of the formula</td>
<td>Explain the meaning of and substitute numbers into formulae. In simple cases change the subject of a formula using inverse operations</td>
</tr>
</tbody>
</table>
Notes for tutors

You will be modelling a possible starter strategy here. Refer to session 5 when you are planning and refer to this activity during session 5.

2.3 Calculators 10 minutes

Use OHT 10 to explain the expectations of pupils when using calculators

**OHT 10**

**Calculator methods**

By the end of Year 6 pupils should have the following skills:

- select the number of figures from the display appropriate to the context of the calculation
- enter numbers and interpret the display for money, metric measurements, units of time and fractions
- know the order in which to use the keys
- know when and when not it is appropriate to use a calculator
- draw on skills of rounding and mental calculation to get a sense of the size of the answer

Say that

The NNS recommends that calculators are used to enable pupils in primary schools to learn about numbers and place value as well as a calculating tool (p8 NNS Framework). It also outlines the skills pupils need to use calculators: how to enter numbers such as measurements or fractions; the order in which to use the keys; how to read the display etc. When the calculator is used to work out an answer, pupils should be able to use the strategies they have learned for estimating and approximating the answer to get a sense of whether their answer is correct.

Pupils should arrive in Year 7 with these skills.

Give out Handout 11.
<table>
<thead>
<tr>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>When using calculators know how to key in money and measurement of time calculations, input a negative number, consider the approximate size of an answer before and after a calculation and, where necessary check it appropriately. Interpret a rounding error.</td>
<td>Know how to use the memory and/or bracket keys</td>
<td></td>
</tr>
</tbody>
</table>

Refer to the objectives from the Key Stage 3 strategy to outline the expected progression in calculator skills.

Say that there is an issue regarding which calculator pupils should use, whether it is a simple four-function model or a scientific or graphical calculator. Teachers need to be familiar with the different types so they can help pupils.

Take a few moments to ask participants if the school or department have a policy for calculator use and what types of calculator they have in their department. Are they suitable?

Keep the discussion brief. Try to focus on solutions and good practice.

**Notes for tutors**

*It might be helpful to have a range of different calculators so that participants can use the different types. You might want to use the activity in 'Numeracy across the curriculum' Unit 6 p157 to illustrate the difference between scientific and basic calculators.*
2.3 Plenary

Show participants OHT1 and ask them to consider whether they have a better understanding of the second objective. Invite them to complete the evaluation sheet.

Session 3

Scales and graphs

Objective
- To provide a range of strategies to help participants to develop pupils’ graph work in the context of science

Timing

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>3.1 Scales</td>
<td>10 minutes</td>
</tr>
<tr>
<td>3.2 Selecting scales for graphs</td>
<td>15 minutes</td>
</tr>
<tr>
<td>3.3 Interpreting graphs</td>
<td>15 minutes</td>
</tr>
<tr>
<td>3.4 Plenary</td>
<td></td>
</tr>
</tbody>
</table>

3.1 Scales

Say that

Pupils sometimes have difficulty reading scales on instruments. A lot depends on the nature of the scale and whether it is straight or curved.

Use OHT 12 as an illustration.
Ask participants which of these scales their pupils would find the most difficult to read and why.

Pupils' familiarity with number lines can be used to help them not only to read the scale but also to use the scale for finding differences in readings.

Use OHT13 and show how pupils could use a paper copy of the scale as a number line to work out differences in readings.

Refer to some of the strategies from session 2.

**Example**
The temperature at the beginning of the experiment was $-10^\circ$C; at the end it was $62^\circ$C. What is the increase in temperature?
Give other examples in science for example timing using a stopwatch, measuring the extension of a spring etc.

Use OHT 14 to demonstrate how a straight number line can be curved to model the scale on an instrument. Show, by doing a simple calculation of the difference between two readings, how this enables pupils to transfer their skills reading straight scales to curved ones.

---

Use Handout 15 to show participants a strategy that can be used to help pupils read curved scales. Say that pupils can use the scale as a number line. It can then be curved and used to demonstrate that it is still the same and therefore can be used in the same way.
Handout 15

| 0  | 2  | 4  | 6  | 8  | 10 | 12 | 14 | 16 | 18 | 20 |

Cut out the scale.

Make the incisions and curve.

3.2 Selecting scales for graphs 15 minutes

Give out and refer to Handout 16 (objectives for Years 7-9).
### Handout 16

<table>
<thead>
<tr>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggest suitable scales for the axes, based on the range of values to be graphed. Know that scales are usually marked with multiples of the value at equal spaces along the axis</td>
<td>Choose suitable scales for the axes. Begin to recognise that the choice of different scales and starting points can have a significant effect on the appearance of the graph and can mislead or leave data open to misinterpretation</td>
<td></td>
</tr>
<tr>
<td>Discuss and begin to interpret graphs of linear functions</td>
<td>Discuss and interpret graphs from a range of sources. Give plausible explanations for the shape of graphs</td>
<td>Discuss and interpret a range of graphs arising from real situations</td>
</tr>
<tr>
<td>Discuss and interpret straight line graphs form science</td>
<td>Discuss and interpret line graphs from other subjects</td>
<td>Discuss and interpret linear and non linear graphs form other subjects</td>
</tr>
</tbody>
</table>

### Notes for tutors

More detail regarding the objectives are in the Key Stage 3 Framework for teaching mathematics, in particular refer to page 173 for an example of the importance of selecting an appropriate scale for a graph.
Say that

In Year 6 pupils are expected to begin to draw and interpret line graphs. In science this can include cooling curves and other graphs drawn from data that has been collected as a result of an enquiry.

Use the objectives for Years 7 – 9 to show how these skills are developed.

Despite the work in mathematics, some pupils still have difficulty selecting scales for graphs. The activities in 3.2 and 3.3 are taken or adapted from the AKSIS book ‘Getting to grips with graphs’ and are reproduced with permission.

Show OHTs 17, 18 and 19.
Use these OHTs to demonstrate how the scale can affect readings, calculations and interpretations using a graph. Ask such questions as ‘What was the mass of the animal after two weeks?’ ‘How much mass did the animal gain in the first six weeks of life?’ ‘How much mass did the animal gain between two weeks and six weeks?’

**Task D**

The scale selector

Allow 10 minutes for this activity.

Give out Handout 20 and a piece of graph paper.
Handout 20
activity

16  The scale selector: 1

1  Make the scale selector

Cut round the dotted line. Fold the paper back along each thick black line.

2  Complete the scale selector

Put each scale in turn alongside the graph paper. Work out the value of one small square and write it on the scale selector.

3  Select the scale for the horizontal axis

<table>
<thead>
<tr>
<th>Height of drop (cm)</th>
<th>Height of bounce (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>30</td>
<td>11</td>
</tr>
<tr>
<td>40</td>
<td>14</td>
</tr>
<tr>
<td>80</td>
<td>19</td>
</tr>
</tbody>
</table>

Look at the biggest number you have to put on the horizontal axis, i.e. 80. Try different scales against the graph paper. Choose the one that goes up to or just beyond your biggest number.

In this case Scale B is best. Copy the scale onto the graph paper.

4  Select the scale for the vertical axis

Look at the biggest number you have to put on the vertical axis, i.e. 19. Turn the scale selector through 90°. Repeat as in step 3.

In this case Scale A is best. Copy the scale onto the vertical axis.
Show how the scale selector is cut out and invite participants to use it to work out the values for one small square on the different scales.

Explain how pupils can use this to select the best scale to fit a graph and how it can be also be used to help them work out values between those marked.
Notes for tutors

This activity and one in 3.3 are also found in the appendix of unit 4. If you know that some of the participants have used these from your work in schools, then you will need to adapt this section.

3.3 Interpreting graphs 

Task E

Allow 10 minutes for this activity.

Give out blank pieces of paper.

Show OHT 21

OHT 21

As you are driving home you notice that you are low on petrol. You know there is no garage on this road until you are almost home. Draw a graph to show the petrol gauge reading and your anxiety level.

Draw a graph to show the length of the grass on your lawn from February until October.

Draw a graph to show how the length of a Mars bar changes as you eat it.

Ask participants to draw a sketch graph for at least one of these scenarios and share it with a colleague, explaining why the graph is the shape it is.

Choose a couple of examples to share with the whole group.

Say that

Task E can be adapted for pupils and used to develop an understanding of the interpretation of the shapes of graphs.

These activities are around expectations for pupils in Years 8 and 9 in mathematics.

The important skills to develop are those of describing the shape of the graph and linking this to an explanation of what it shows.

Review, in a brief discussion, where these skills might be necessary in Key Stage 3 science.
Allow 5 minutes for this.

Notes for tutors

For more detail of outcomes for graphical skills and examples you can use, refer to the Key Stage 3 framework for mathematics p174 – 177.

3.4 Plenary

Show participants OHT1 and ask them to consider whether they have a better understanding of the third objective. Invite them to complete the evaluation sheet.

Session 4

Magnification

Objective

- To provide participants with techniques for developing pupils’ understanding of magnification

Timing 10 minutes

4.1 Magnification
4.2 Plenary

Say that

In science, it is important that pupils develop their understanding of number in terms of size; there are very large numbers e.g. distance to the nearest stars etc. and very small numbers e.g. size of molecules.

Early in Year 7 pupils will use a microscope to look at cells and many have difficulty relating what they see to the size of a cell.

Enlargement does not occur until Year 8 in the Framework for teaching mathematics: Years 7, 8, and 9. The following activities can be used to introduce pupils to the idea of magnification in Year 7 in science when they begin to use microscopes.

Give out Handout 22.

Explain how each of the techniques can be used to develop pupils' ideas of size when using a microscope.
Handout 22

Pupils focus the millimetre scale on a transparent rule under a microscope. This gives them a concrete visualisation of the magnification, as they will be able to see the markings without the microscope as well as with it.

Pupils draw a ‘plant cell’ (rectangle) 2cm x 1cm. They then redraw it twice the linear size, 4cm x 2cm, four times the linear size etc. If appropriate pupils can calculate the area for the different rectangles and find a pattern in the results.

Use a 100 square grid (the mathematics department may have one) to demonstrate the relative sizes of a magnified cell (the whole grid) and a ‘real cell’ (a single square).

Use children’s small building bricks or multi-cubes to build a 2x2 cube. Ask pupils to estimate how many more bricks/cubes will be needed to scale the model up by 2, 3 etc. Check against reality.

Notes for tutors

You should be able to borrow a 100 grid square from your numeracy consultant colleagues.

See also session 5 for a starter activity that is linked to magnification.

4.2 Plenary

Show participants OHT1 and ask them to consider whether they have a better understanding of the fourth objective. Invite them to complete the evaluation sheet.

Session 5

Starter activities

Objective

- To provide participants with the opportunity to develop numeracy starter activities for science lessons

Timing

| 5.1 Characteristics of starter activities | 10 minutes |
| 5.2 Examples of starter activities | 15 minutes |
| 5.3 Plenary | 25 minutes |
5.1 Characteristics of starter activities

Say that

Starter activities can be used for a variety of purposes including links to prior learning, revision of work needed to enable pupils to make progress and ‘tuning pupils in’ to the current work.

In a lesson where pupils will be using mathematical processes the starter activities could productively be mathematical.

Show and explain OHT 23

OHT 23

Starter activities should:

- give a clear start to the lesson
- have a brisk pace
- have a range of different questions.

Support staff should be briefed regarding their role.

Refer to different techniques for questioning, developing pupils’ confidence to answer and strategies such as the use of white boards for pupils to record their answers.

Notes for tutors

The Science and literacy unit and the notes you have on effective lessons have details of different starter activity techniques.

5.2 Examples of starter activities

Task F

Allow 15 minutes for this activity.

Divide participants into groups of two/three.

Ask each group to devise at least one numeracy starter activity that could be used at the beginning of a lesson where pupils were going to be required to use a mathematical concept or process. Include reference to the science lesson where this could be used.

After five minutes take feedback and collate ideas.
Notes for tutors

These can be typed up and circulated to participants.

Give out Handout 24.

Handout 24

Numeracy starter activities – some examples.

The teacher describes a graph shape e.g. it begins at the origin, rises steeply then levels off and becomes a straight line etc. The pupils draw it on a white board and hold them up for the teacher to see.

The teacher shows pupils a graph and asks them to describe relationships. Pupils are encouraged to use comparative adjectives.

Show an OHT of a scale and ask pupils to read off various points. Ask them to work out differences between two points.

Ask pupils to estimate sizes and distances of different objects. This could be linked to work done using a microscope or to develop an understanding of the magnitude of an answer to a calculation.

Use an OHT of a graph and ask pupils to read off (or record on a white board) different values.

Put a ‘washing line’ across the classroom. Ask pupils to peg cards of different pictures/words in the correct sequence according to the size of the object described.

Say that this, together with their own ideas, can be used to develop a bank of starter activities that can be incorporated into the scheme of work.

Notes for tutors

It might be helpful if you could demonstrate some of the starter activities described in Handout 24.

5.3 Plenary

Show participants OHT1 and ask them to consider whether they have a better understanding of the fifth objective. Invite them to complete the evaluation sheet.
Session 6

Plenary and introduction to follow-up work

Objectives

- To agree the follow-up work that will take place in schools
- To complete the evaluation form

Timing

<p>| | |</p>
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<tbody>
<tr>
<td>6.1</td>
<td>Follow-up activities</td>
</tr>
<tr>
<td>6.2</td>
<td>Evaluation</td>
</tr>
</tbody>
</table>

6.1 Follow-up activities

Introduce the participants to the nature and purpose of the follow-up activities.

Make these key points.

- These are intended to provide a focus for continuing work between the consultant and the science department in reviewing and developing practice in schools.

- The activities are intended to enable any issues raised in this training to be addressed back in school.

Try to get as much agreement as possible for the follow-up work before participants leave. If it is not possible, make sure that the next time you contact the school, you follow this up and set dates for review and completion of tasks related to this unit.

Say that

Participants should choose one or more of the follow-up tasks.

Alternatively they can negotiate specific support relating to science and numeracy with the consultant.

Alternative tasks

Working with the consultant, try some of the strategies and evaluate their effectiveness in enhancing pupils’ numeracy skills.

Highlight areas in your scheme of work where numeracy is an issue. Share with colleagues and devise a range of strategies to support pupils.
For any cross-curricular priorities not covered but which are an issue in your school, discuss with the consultant and/or your mathematics department what strategies you could use to help pupils.

6.2 Evaluation

Complete evaluation forms and depart.
Appendix 1

National Curriculum for Science
Key Stage 3

Links to other subjects

Scientific enquiry

2e decide the extent and range of data to be collected and the techniques, equipment and materials to use
builds on Ma4/1a, 2c

2g make observations and measurements, including the use of ICT for datalogging
builds on Ma3/4a and Ma4/3a, 3b

2i use a wide range of methods, including diagrams, tables, charts, graphs and ICT to represent and communicate qualitative and quantitative data
builds on Ma4/4a, 4b, 4h

2j use diagrams, tables, charts and graphs, including lines of best fit, to identify and describe patterns or relationships in data

2k use observations, measurements and other data to draw conclusions

2l decide to what extent these conclusions support a prediction or enable further prediction to be made

2m use their scientific knowledge and understanding to explain and interpret observations, measurements or other data and conclusions

2n consider anomalies in observations or measurements and try to explain them

2o consider whether the evidence is sufficient to support any conclusions or interpretations made
build on Ma4/5a-5g, 5j

Physical processes

2a how to determine the speed of a moving object and to use the quantitative relationship between speed, distance and time

2f the principle of moments and its application to situations involving one pivot

2g the quantitative relationship between force, area and pressure and its application
build on Ma2/5f