ICT across the curriculum

ICT in science

Department for Education

Key Stage 3
National Strategy

ICT across the curriculum

ICT in science

Guidance

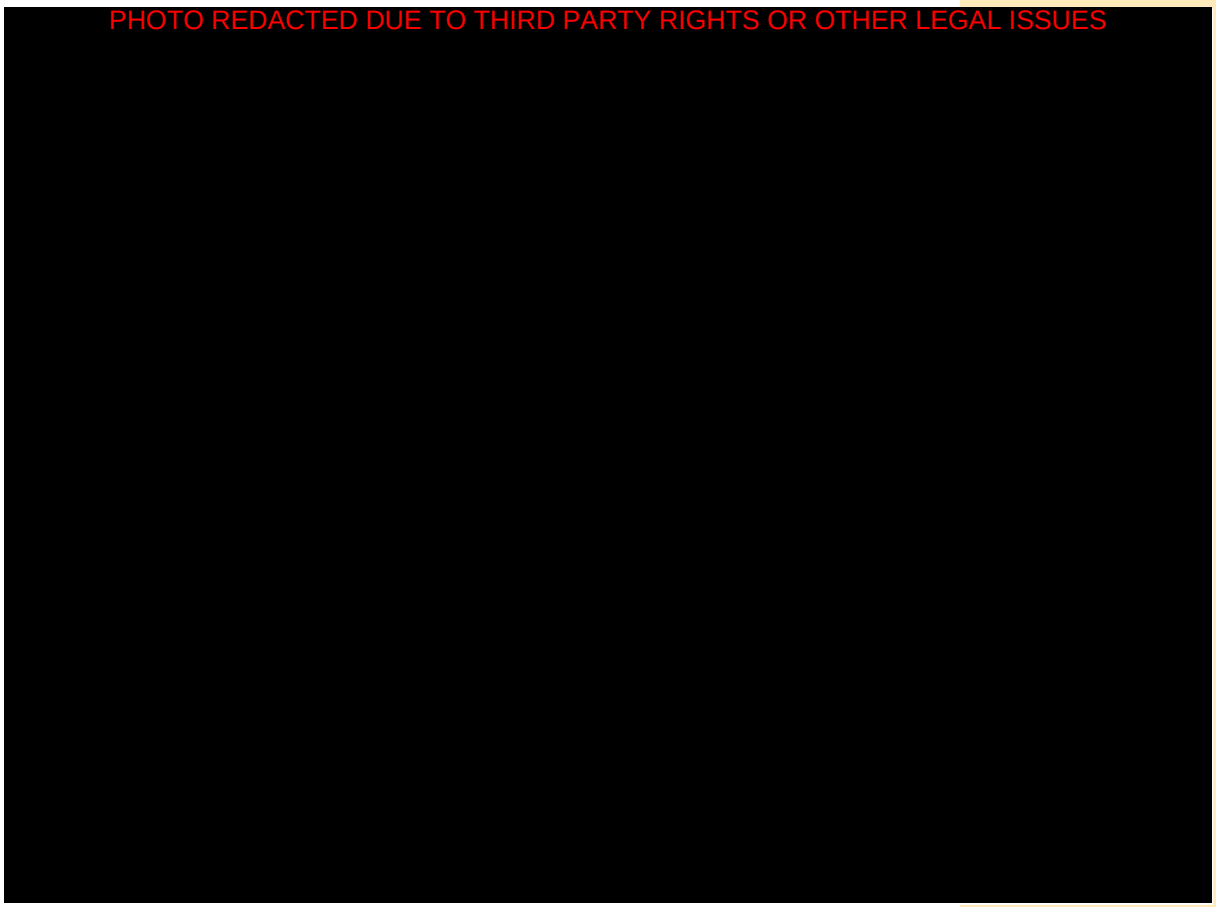
Curriculum and Standards

ICT consultants and tutors

Status: Recommended

Date of issue: 09-2004

Ref: DfES 0178-2004 G



department for
education and skills
creating opportunity, releasing potential, achieving excellence

Key Stage 3
National Strategy

ICT across the curriculum
ICT in science

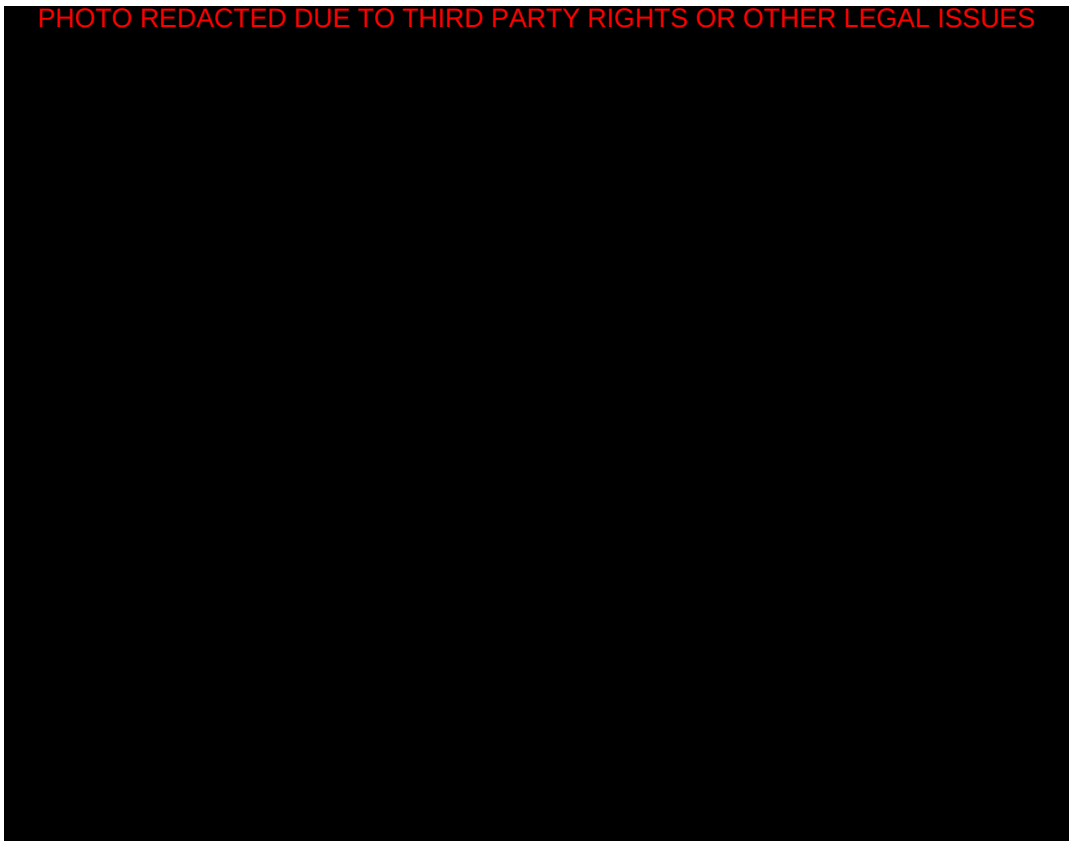
department for
education and skills
creating opportunity, releasing potential, achieving excellence

Disclaimer

The Department for Education and Skills wishes to make it clear that the Department, and its agents, accept no responsibility for the actual content of any of the materials suggested as information sources within this document, whether these are in the form of printed publications or on a website.

Inclusion of, or references to icons, logos or products including software in these materials, as exemplars or for contextual or practical reasons, should not be interpreted as an endorsement of such companies or their products.

Contents



Introduction

About the *ICT across the curriculum* (ICTAC) pack

The training pack for *ICT across the curriculum* (ICTAC) forms part of the Key Stage 3 National Strategy's support for whole-school improvement. It should be used flexibly to suit local circumstances and, if you have chosen ICT across the curriculum as your whole-school priority, will be supported by your local Key Stage 3 lead consultant for ICTAC.

The *ICT across the curriculum* (ICTAC) pack is a set of materials designed to promote the use of ICT across all subjects in schools. It builds on the work of the Key Stage 3 National Strategy ICT strand and the ICT capability that pupils are bringing to their subject lessons from their ICT lessons. It also considers the value that ICT can add to teaching and learning in subjects and the need for a whole-school approach to develop coherent and effective practice across the curriculum.

The training pack comprises:

- a management guide;
- a series of *ICT in …* printed guides (one per subject);
- exemplification materials on the subject-specific CD-ROMs;
- case study video on the subject-specific CD-ROMs;
- subject-specific A2 colour posters describing use of ICT capability (two per subject).

About this *ICT in science* guide

This *ICT in science* guide is intended for subject leaders and teachers.

The main objectives of this publication are to:

- raise awareness of how the ICT capability, as set out in the National Curriculum for ICT and taught in ICT lessons, can be applied and developed in science;
- analyse the opportunities that exist in science for developing and applying pupils' ICT capability;
- consider how ICT can add value to the teaching and learning of science.

> The past five years have seen a slow but steady improvement in pupils' achievements in ICT capability, the quality of teaching, and the leadership and management of ICT … The complementary use of ICT across subjects, however, has been slow to develop and is uneven across schools and subjects …
>
> The effective balance between the teaching of ICT skills, knowledge and understanding on the one hand and the application of these as part of learning across subjects on the other hand remains a difficult and elusive goal for the majority of schools.
>
> *(Information and communication technology in secondary schools: Ofsted subject reports 2002/03)*

1 Introduction to ICT across the curriculum

ICT capability

What do we mean by 'ICT capability'?

ICT capability involves technical and cognitive proficiency to access, use, develop, create and communicate information appropriately, using ICT tools. Learners demonstrate this capability by applying technology purposefully to solve problems, analyse and exchange information, develop ideas, create models and control devices. They are discriminating in their use of information and ICT tools, and systematic in reviewing and evaluating the contribution that ICT can make to their work as it progresses.

ICT capability is much broader than acquiring a set of technical competencies in software applications, although clearly these are important. ICT capability involves the appropriate selection, use and evaluation of ICT. In essence, pupils need to know **what** ICT is available, **when** to use it and **why** it is appropriate for the task.

For example, when pupils are creating a presentation, they use their ICT capability to select appropriate software, consider fitness for purpose and match content and style to a given audience. It is important that lessons are not driven by software or technology but are focused on clear objectives in science, where ICT is used as a vehicle to support achievement of those objectives and to enhance teaching and learning in science.

Requirements for ICT in the National Curriculum

There are two statutory responsibilities within the National Curriculum for teaching ICT in schools at Key Stage 3. Schools need to ensure that all pupils are:

- **taught** the programme of study, at each key stage, as set out in the *National Curriculum for Information and communication technology* – the attainment target, ICT capability, sets out the expected standard of pupils' performance required at each level;
- given opportunities to **apply and develop** their ICT capability through the use of ICT tools to support their learning in all subjects.

The first bullet point focuses upon teaching ICT as a subject, whereas the second point refers to applying the subsequent ICT capability across other subjects.

ICT – the subject

In this publication, 'ICT – the subject' refers to the teaching of the National Curriculum for ICT. Advice on how ICT can be taught as a subject is detailed in the Key Stage 3 National Strategy publication, the *Framework for teaching ICT capability: Years 7, 8 and 9* (DfES 0321/2002). The Framework breaks down the Key Stage 3 ICT programme of study into yearly teaching objectives. It also recommends that schools should allocate a minimum of one hour per week for discrete ICT teaching in each year of Key Stage 3, to ensure sufficient time for the programme of study to be taught effectively.

The Strategy's guidance about how to teach ICT capability as a subject is extensive. A series of sample teaching units, developed from the QCA/DfEE publication, *A scheme of work for Key Stage 3 information and communication technology*, includes detailed lesson plans and resources showing how the ICT yearly teaching objectives can be taught in lessons. The units are intended to provide a stimulus for planning, for individual schools to adapt and integrate within their own schemes of work.

All of the materials and guidance for teaching ICT as a subject are available on the website for the Key Stage 3 National Strategy (**www.standards.dfes.gov.uk/keystage3**). Teaching ICT as a subject is therefore not the focus of this publication, but there are clearly overlaps with the use of ICT in other subjects that should be considered. Consequently, this and related publications include guidance about how pupils can be given opportunities to apply and develop their ICT capability in other subjects, and how these relate to the teaching of ICT as a subject.

ICT – in subjects

Successful implementation of the ICT strand of the Key Stage 3 National Strategy will give pupils a sound level of ICT capability and the transferable skills to build upon in their learning of other subjects. This has implications for teachers across all subjects in the curriculum.

Pupils will come to science lessons with expectations about how they might apply ICT to move their own learning forward. Science teachers will not need to teach ICT capability but can exploit new opportunities for pupils to apply and develop the capability that they already have, to enhance their learning in science. Consequently, the focus of the lesson remains firmly rooted in science and teachers are not burdened with the need to teach ICT.

There are implications for subject teachers, in that they will need a good understanding of the breadth of ICT capability that pupils have been taught and will be bringing to their lesson. This is explored later in this section. Teachers will also need to know which parts of ICT capability offer significant opportunities for teaching and learning in science and how they can be incorporated into existing schemes of work. This is explored in detail in sections 2 and 3. The use of ICT needs to be purposeful and to add value to the teaching and learning of science and should not be seen simply as a bolt-on. It needs to be carefully integrated into science lessons, with a clear rationale for its use. Some examples of lessons are outlined in section 4 and included, in full, on the accompanying CD-ROM.

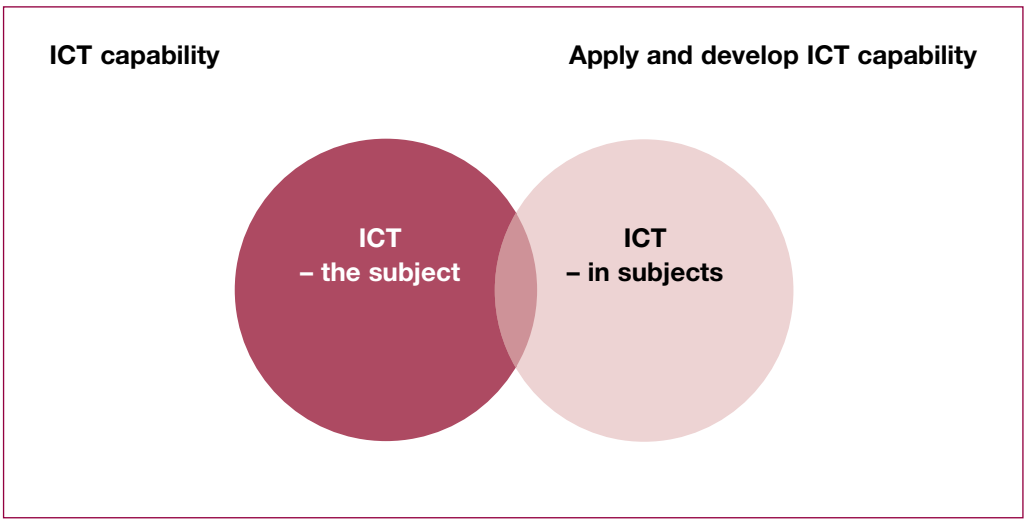
The relationship between 'ICT – the subject' and 'ICT – in subjects'

Pupils' ability to apply their ICT capability across the curriculum is largely dependent on the effective teaching and learning of ICT in the first place. Pupils' use of ICT in other subjects may be ineffective if they do not already have an appropriate level and understanding of ICT capability. This may result in a lack of progress in both ICT and the subject area. For example, asking pupils to produce a presentation in science will be unproductive if they have little experience of using the software or understanding of how to create meaning and impact for a given audience. Pupils who try to learn new areas of ICT at the same time as new science content will often fail in both endeavours.

It is crucial that pupils are taught the appropriate ICT capability before applying it in other subjects. The relationship between 'ICT – the subject' and 'ICT – in subjects' can therefore be viewed as interactive and mutually supportive as shown in the diagram on the next page.

Purposeful and appropriate application of ICT in subjects offers pupils opportunities to:

- use their ICT capability to assist and progress their learning in science;
- engage in higher-order thinking skills, for example, by using ICT to undertake detailed analysis when modelling data;
- demonstrate, apply and reinforce their understanding of ICT capability within a range of subject contexts. The transferability of ICT capability is an important aspect of progression in pupils' knowledge, skills and understanding.



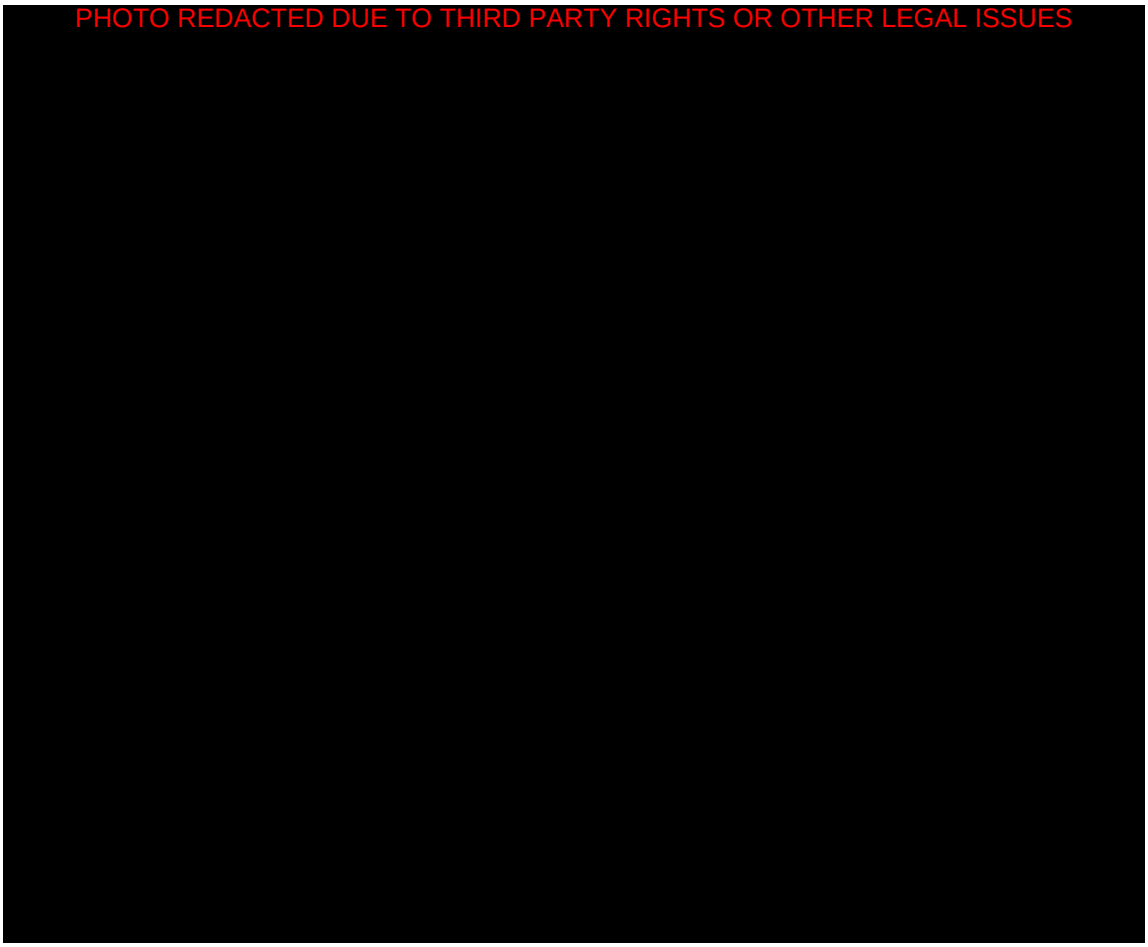
It is important to recognise that pupils using ICT effectively in subjects may not always be applying high levels of ICT capability. For example, using a wordprocessor to draft and redraft text is a valid and powerful activity in a range of subjects; using software to support learning in MFL or using a learning support program in mathematics or a bespoke program designed to aid learning in science can be significant in helping pupils to make progress. In all such cases, ICT fulfils a legitimate function if using it moves learning in the subject forward, but it may make little contribution to developing the ICT capability taught in ICT lessons.

As pupils become more confident and proficient in using ICT there will be opportunities to apply and develop higher levels of ICT capability in subjects, for example, producing web pages for a given purpose and audience, manipulating data to test a hypothesis, or incorporating sound and video into a presentation to add meaning and impact. It is important to reiterate that, whatever the level of ICT capability applied, it must add value to teaching and learning in the subject.

Although the *Framework for teaching ICT capability; Years 7, 8 and 9* (DfES 0321/2002) recommends that schools allocate discrete ICT teaching time in all years at Key Stage 3, it will be for schools to decide which is the most effective model. There may be some opportunities for aspects of ICT capability to be taught in a different subject area and then also applied in an appropriate context. For example, the control elements of the National Curriculum for ICT could be taught within design and technology. However, teaching subject objectives and ICT objectives at the same time can be problematic and teachers should be aware of the potential for the lesson to lose sight of the ICT objectives. Progress in the teaching and learning of a particular subject can also be disrupted by the time taken to teach the required ICT component from scratch.

> Many schools continue to cling to a belief that cross-curricular provision can deliver good progression in ICT capability, in spite of inspection evidence to the contrary over recent years. The weight of evidence suggests that what works best is a balance between discrete provision and the application of ICT capability across other subjects. However, many schools continue to struggle to achieve this.
>
> *(Information and communication technology in secondary schools: Ofsted subject reports 2001/02)*

An integrated approach to ICT across the curriculum



A whole-school policy for ICT across the curriculum

Schools put considerable investment into ICT resources. However, this investment alone will not necessarily give pupils appropriate opportunities to apply and develop ICT capability – nor automatically add value to teaching and learning. Effective implementation of ICT across the curriculum is much more complex and involves strategic management and coordination within whole-school policies. An effective model of applying and developing ICT across the curriculum depends on a number of factors, including:

- effective teaching of the National Curriculum programme of study for ICT (the subject);
- appropriate opportunities for pupils to apply and develop ICT capability in a range of subjects and contexts (transferable knowledge, skills and understanding);
- deployment of resources so that subject areas can access ICT when it is needed, including provision of ICT within subject classrooms or areas;
- a policy for purchasing of resources that maximises their use and allows for flexibility of use, for example, whole-class teaching, small-group work, individual teacher use – this could include consideration of whole-school networking provision, laptops and wireless networking capability;
- planned use of ICT in schemes of work for all subjects, so that resources can be deployed and organised appropriately;
- whole-school policies which clearly map and sequence opportunities for application and development of ICT, so that pupils bring the appropriate ICT capability to subject lessons;
- whole-staff awareness of ICT capability and what can reasonably be expected of pupils in each year.

Key concepts in the *Framework for teaching ICT capability: Years 7, 8 and 9*

The National Curriculum programme of study for ICT groups the knowledge, skills and understanding that pupils need to acquire into four themes:

- finding things out;
- developing ideas and making things happen;
- exchanging and sharing information;
- reviewing, modifying and evaluating work as it progresses.

The *Framework for teaching ICT capability: Years 7, 8 and 9* (DfES 0321/2002) subdivides each of the first three themes into three key concepts. The resulting nine key concepts describe the breadth of ICT capability and progression in learning through Key Stage 3. This provides a useful vehicle when discussing how ICT can most enhance teaching and learning in subjects. The fourth theme (reviewing, modifying and evaluating work as it progresses) is a critical feature of ICT capability, which needs to be integrated throughout all areas.

ICT capability Key Stage 3
Key concepts

Key to ICT National Curriculum themes:

- Finding things out
- Developing ideas and making things happen
- Exchanging and sharing information
- Reviewing, modifying and evaluating work as it progresses

The diagram above shows the nine key concepts of ICT capability. Further guidance about each of these concepts can be found in Appendix 1.

In the ICT Framework, each key concept is broken down into suggested yearly teaching objectives in Years 7, 8 and 9, to identify progression through the key stage. The yearly teaching objectives are displayed in full in Appendix 2.

The breakdown of ICT capability into the nine key concepts shown in the diagram helps identify the most appropriate areas of ICT to enhance teaching and learning in subjects. It is important that pupils are given sufficient opportunities to develop and apply the full range of their ICT capability in the curriculum.

Planning and sequencing ICT across the curriculum

Subject teachers need to know what they can reasonably expect a pupil to know, understand and be able to do at each point in Key Stage 3.

Schools will need to map and sequence the teaching of ICT capability. This will identify when subject teachers can reasonably expect to develop and apply pupils' ICT capability and move teaching and learning forward in their own subject teaching and learning. For example, once pupils have been taught appropriate search techniques on the Internet, including consideration of validity and bias, they can be expected to undertake purposeful research in other subjects and present their findings.

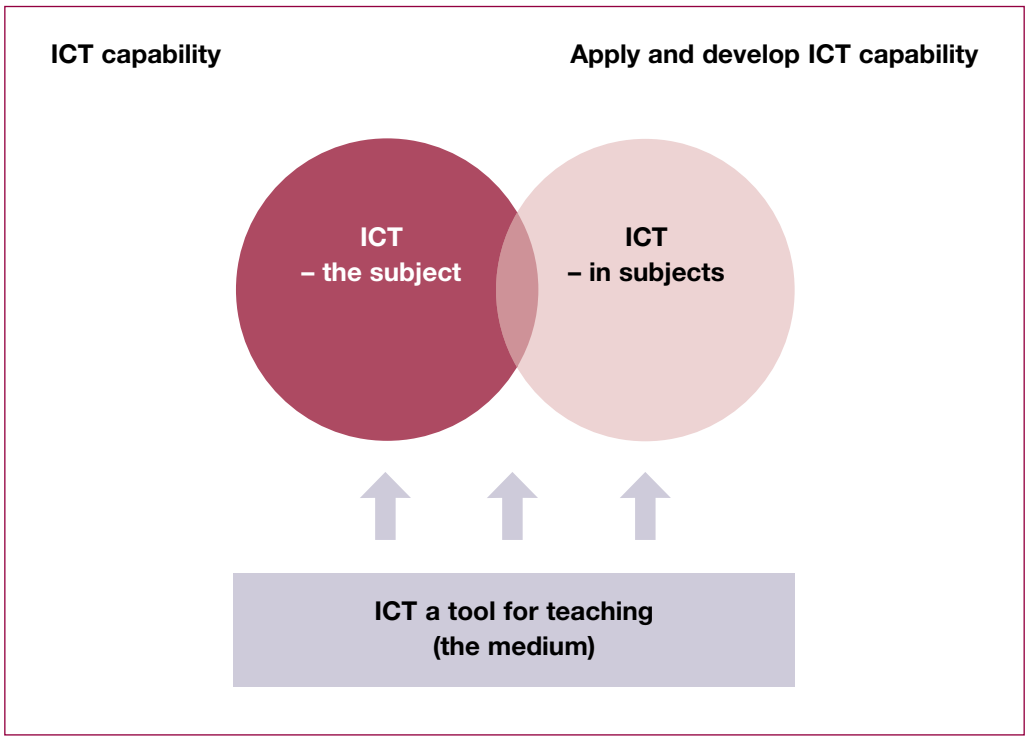
It is also important to consider the experiences of pupils at Key Stage 2. Again, individual schools will differ but Appendix 3 (extracted from the *Framework for teaching ICT capability: Years 7, 8 and 9* (DfES 0321/2002)) describes what most pupils should have learned in ICT by the end of Key Stage 2. This summary is based largely on pupils following the Key Stage 2 QCA scheme of work, or equivalent, during Years 5 and 6.

ICT as a teaching tool

So far we have reviewed the use of ICT as a learning tool for pupils and have acknowledged how pupils who are confident and proficient in ICT can bring with them opportunities for extending their **learning** as they use their ICT in other subjects in the school curriculum.

However, existing and emerging ICT **teaching** tools provide further opportunities to enhance subjects and add value to teaching and learning. For example, the use of interactive whiteboards, video projection units, microscopes connected to computers, prepared spreadsheets to capture and model data, CD-ROMs, presentations with video and carefully selected resources from the Internet all provide examples of how ICT can be embedded into subject teaching.

The diagram on page 9, showing ICT across the curriculum, can therefore be extended to include ICT as a tool or medium for teaching.



Clearly elements of the model will overlap and impinge on each other. For whole-school policies for ICT across the curriculum the challenge is to make the most purposeful use of the available resources across all teaching and learning. Opportunities to embed ICT suitably in subject-teaching need to be exploited, as appropriate.

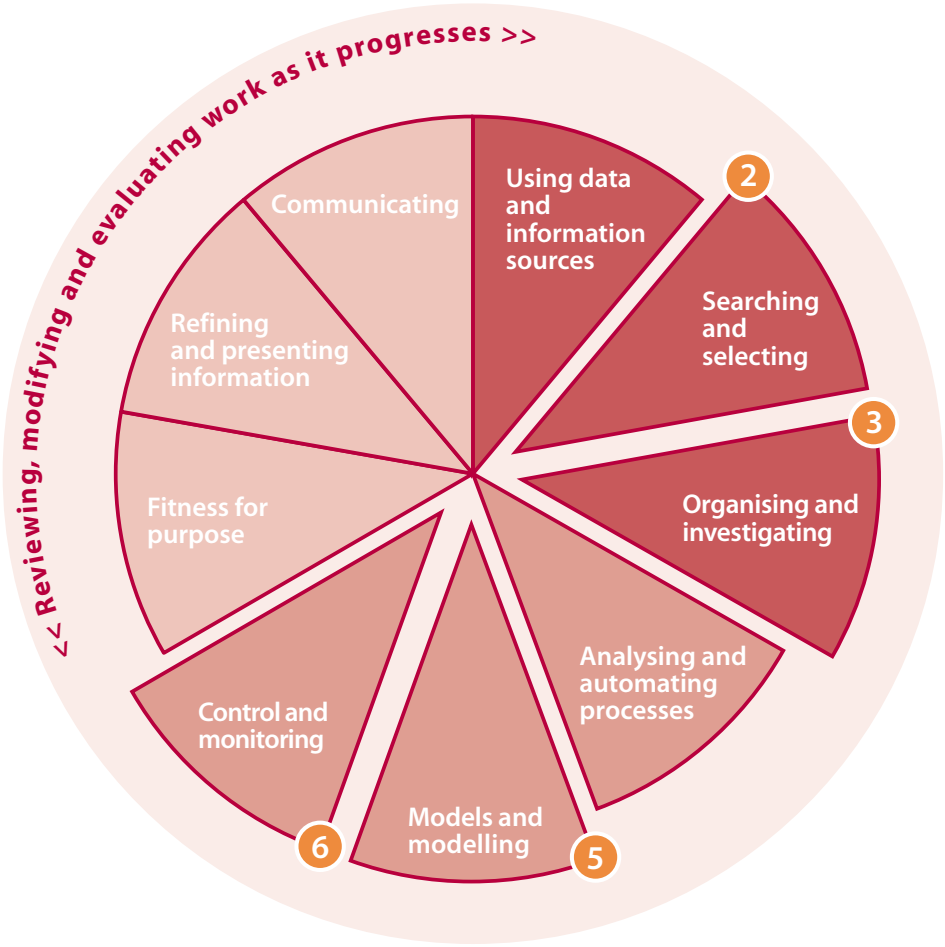
Use of ICT by a teacher may involve little or no use of ICT by pupils and, consequently, may do little to apply and develop their ICT capability. However, use of ICT by the teacher can enhance and stimulate the learning experiences of pupils and contribute to the achievement of subject objectives. It is important to recognise the different contributions that ICT can make to teaching and learning and acknowledge the importance of each. A policy for ICT across the curriculum should consider all these elements and the relationships between them.

Some examples of how this could be done in science are outlined in section 4 and included in detail on the accompanying CD-ROM.

The DfES CD-ROM, *Embedding ICT @ Secondary*, also provides a series of subject-specific case studies focusing on teacher-use of ICT.

Key concepts

The diagram introduced on page 11 has been expanded to highlight some of the ICT key concepts that are particularly significant for science. These are expanded further on the *ICT in science* poster (DfES 0201–2004G) that accompanies this pack.



Key to ICT National Curriculum themes:

- Finding things out
- Developing ideas and making things happen
- Exchanging and sharing information
- Reviewing, modifying and evaluating work as it progresses

2 Commentary: ICT and science

An overview

The expectation is that pupils will have been taught all nine key concepts of ICT capability in their ICT lessons. This provides the foundation for the application and further development of these ICT key concepts across the curriculum. The nine key concepts are shown in the diagram on the opposite page.

Although many of the ICT key concepts could be applied and developed in science, some are more significant than others. The four key concepts, highlighted in the diagram, that are particularly significant for science are:

- searching and selecting;
- organising and investigating;
- models and modelling;
- control and monitoring.

Other key concepts could also be applied and developed in science. For example, the key concept of **using data and information sources** could be developed within science with the Internet providing a very rich source of information for pupils to interrogate.

How can the use of ICT raise standards in science?

ICT can be used as a tool to:

- support teachers:
  - to improve lesson design;
  - to transform teaching and learning;
  - to engage and motivate pupils to learn more effectively;
- provide opportunities for pupils to learn in alternative and challenging ways, using a wide range of sources of information and techniques to support critical thinking;
- support both individual and collaborative work;
- enable pupils to:
  - see patterns or behaviours more clearly;
  - add reliability or accuracy to measurements;
  - engage in whole-class discussion regarding first-hand observations;
  - consider issues raised by their observations within a wide range of industrial and social contexts;
- help pupils refine and present their ideas more effectively and in different ways.

Further guidance on *Using ICT in Key Stage 3 science* can be found on pages 46 and 47 of the *Framework for teaching science: Years 7, 8 and 9* (DfES 0136/2002).

Planning and progression

Teachers should expect pupils in any given year to have covered all or most of the objectives in the *Framework for teaching ICT capability: Years 7, 8 and 9* (DfES 0321/2002) from the previous year. Science teachers may also wish pupils to apply ICT capability learned during the year in which they are being taught. It is important to liaise with the ICT department to ensure that the levels of expectation and challenge are appropriate to pupils' experiences and levels of ICT capability.

To ensure the effective use of ICT in science, teachers should:

- plan the use of ICT by pupils in collaboration with the ICT department, to ensure that pupils have appropriate ICT skills;
- analyse how to build on prior learning in science and ICT, to inform planning of schemes of work and design of lessons;
- be sure that ICT resources are available for the lesson.

It is important to plan for a range of ICT uses, to ensure that pupils' capability is developed and consolidated as they progress, both in science and in the use of ICT. In particular, teachers should plan to use ICT in science lessons at a level that pupils have already covered in ICT lessons.

Teachers will need to ensure that:

- pupils' use of ICT is varied but appropriate to their learning in science;
- as pupils' ICT capability increases, they are given further opportunities to apply and develop aspects of that capability in science lessons.

It may be appropriate to use low-level ICT skills to enhance learning in science, but pupils should also be given opportunities to apply higher-order skills. This should enable pupils to further enhance their learning in science as well as develop their ICT capability. Using higher-order ICT skills will also increase pupils' motivation by providing new opportunities for learning that could not be achieved easily in other ways.

Awareness of pupils' capability in ICT will enable teachers to plan lessons that use and apply ICT in ways that help challenge and motivate pupils of all attainment levels. It is expected that:

- Year 6 ICT capability will support Year 7 work in science;
- Year 7 ICT capability will support later Year 7 and Year 8 work in science;
- Year 8 ICT capability will support later Year 8 and Year 9 work in science;
- Year 9 ICT capability will support both later Year 9 work in science and GCSE work.

Appendix 2, *Yearly teaching objectives for ICT*, and Appendix 3, *End of Key Stage 2 expectations*, provide a useful starting point for this, but practice in individual schools will vary, depending on how and when the National Curriculum for ICT is taught.

Planning to use ICT in science lessons

Effective communication between the science and ICT departments will foster a clear understanding of the timescale during which pupils should have developed the different ICT capability in each year. Science teachers need to identify opportunities to exploit pupils' capability in ICT to move learning in science forward. They also need to consider whether the use of ICT is appropriate to the aspect of science being taught.

When planning to use ICT in lessons, teachers should consider whether:

- the ICT is adding value to the lesson:
  - Would the science learning outcomes be achieved as or more efficiently without the use of ICT?
  - Is the identified form of ICT (both hardware and software) the most appropriate one to use?
- there are opportunities in the plenary for pupils to communicate their understanding of how ICT has contributed to their learning in science;
- schemes of work reflect a range of uses of ICT:
  - by pupils, to consolidate and develop their ICT capability;
  - by teachers, to support teaching of the National Curriculum for science.

3 ICT themes and key concepts in science

This section identifies some of the opportunities for applying and developing pupils' ICT capability that can be built into medium- and short-term planning in science. It considers ICT key concepts that offer significant opportunities to enhance pupils' learning in science and gives some brief examples of how this could happen in classrooms.

This symbol indicates that the lesson is based on one that is described in detail on the accompanying CD-ROM.

Searching and selecting

The use of ICT allows pupils to search and select from a variety of information sources. They can interrogate the data to identify correlations, recognise patterns, test hypotheses and make predictions.

The ICT objectives for Year 7 and Year 8 concentrate on finding secondary data, while in Year 9 they are about setting up investigations to obtain primary data. Both these approaches fit science well, particularly in the area of scientific enquiry. In science, pupils analyse high volumes of data, usually in the form of databases. They will need the necessary skills to interrogate the data in order to identify patterns. All the ICT objectives for Year 9 relate to scientific enquiry skills that are developed throughout Key Stage 3 and which continue to be developed during Key Stage 4.

In Year 7, pupils researched the life of a famous scientist. Another Year 7 class researched renewable energy resources. During these lessons, pupils in both classes understood that not all sources of information are equally valuable.

In Year 8, following a lesson on diet analysis, using proprietary software, pupils contributed records to a database about food products and their nutrient components. Using refined search methods, pupils located records and used them to construct specialist diets for patients suffering a range of dietary disorders or with special requirements.

Year 9 pupils surveyed their families to collect data about smoking, drugs and exercise. The data were added to a larger dataset which pupils interrogated to identify correlations and patterns, test hypotheses, draw conclusions and make predictions. Pupils reviewed their findings by comparing their conclusions with other (national) surveys, to check the validity and plausibility of their work.

Organising and investigating

Within a scientific enquiry, pupils can use ICT to collect and present data. They can analyse findings and compare them with other information sources to check their validity and plausibility.

Wherever scientific enquiries are being carried out with the aid of ICT, it is likely that some of the objectives for this ICT concept will be met. Survey work could involve the design of questionnaires and in any scientific enquiry there is the key question of how to collect and present the data. A science enquiry in which the data were recorded in a spreadsheet, such as Microsoft Excel™, from which a graph could be generated, provides a significant match with the Year 8 yearly teaching objective (YTO) for **scientific enquiry:** *Use a range of first-hand experience, secondary sources of information and ICT to collect, store and present information in a variety of ways, including the generation of graphs*.

Data-logging involves the use of software to collect and present information in a variety of ways. Pupils can use data recorded in a spreadsheet to create graphs, allowing more time for them to discuss their findings. Data stored on a CD-ROM can provide opportunities for pupils to develop their interpretation and analysis skills. Multimedia software can also be used to provide the context for enquiry work.

Year 7 pupils investigating the speed of a moving object used ICT to collect data. Two light gates were set up alongside a ramp, down which a toy car was released. They used a data-logger to record the time taken by the car to travel between the two light gates. Pupils altered one variable (height or angle of ramp, or distance down ramp) and timed the car again. They recorded the collected results in a spreadsheet, using a suitable format selected by the pupils.

Other examples of suitable investigations include:

- the factors affecting the strength of an electromagnet (Year 8 pupils);
- the effect of light levels on the rate of photosynthesis as indicated by evolution of oxygen (Year 9 pupils).

Models and modelling

Pupils can use ICT to create models to develop scientific concepts and explore understanding by asking 'What if …?' questions. They can modify rules and variables to explore the science of the model, predict outcomes and test hypotheses.

The use of models, modelling and analogies is central to the teaching of science and is broader than that indicated by the ICT yearly teaching objectives. The emphasis in most science lessons will be on questioning or making predictions, based on the scientific model, rather than any underlying ICT. This could involve the use of programs to model a process and observe outcomes when the process or inputs are changed. For example, pupils could use ICT techniques to predict and observe the consequences of changing the temperature or pressure in the Haber process.

It is important to be clear about the nature of the model being used and to share this with pupils. Teachers need to clarify whether the model is a scientific one, as in particle theory, or a teaching one, for example, arranging pupils to represent the particles in a solid, liquid or gas. Commonly-used teaching models include software products designed to illustrate a specific scientific concept, which use modelling techniques to develop pupils' thinking. Increasingly as they move through their science curriculum, pupils are asked to consider a wider range of scientific and teaching models (not ICT-based), to consider the strengths and weaknesses of models and to develop their own models to explore a range of phenomena. Pupils are asked to use packages such as Microsoft Excel™ to develop simple models but are rarely asked to test or modify them. By using ICT, pupils could gain more experience of using models to test their own hypotheses and predictions, and hence would be applying some of the Year 9 yearly teaching objectives for ICT.

Multimedia software, designed to illustrate scientific models, can be used to help pupils develop their understanding of topics such as particle theory, energy transfers through a food chain, or flow of electric current in a circuit. Such software often allows pupils to modify a restricted range of parameters to explore the science of the model. Through these activities, the limitations of the models will become clear to pupils, even if they are not able to modify them.

Spreadsheets can be used in science to model processes and pupils may modify parameters and discuss the outcomes of those changes. These activities also provide opportunities for pupils to discuss whether the model chosen is the most appropriate for the task.

Pupils in Year 8 used a computer simulation (a teaching model) to investigate the factors affecting the strength of an electromagnet.

Pupils in Year 9 used simulation software to obtain numerical data for the current and potential difference in a range of simple circuits. They identified a mathematical relationship between the sets of data and used it to construct a scientific model which they developed and tested. In this case, the scientific model helped to explain what was happening in the circuits and, at the same time, modelled the process undertaken by research scientists. The type of modelling involved in this lesson required higher-order thinking skills than those required to build a model to visualise a concept. This was an example of the development of a formulaic, mathematical model which was used to identify the proportionality relationship, and which is appropriate for most Year 9 pupils.

Control and monitoring

Using ICT allows pupils to monitor physical conditions and reflect upon the quality and quantity of the data collected. They can then use the data to explore and investigate hypotheses and draw conclusions.

Monitoring is an important part of data-logging lessons in science. Pupils use sensors, attached to data-loggers, to monitor a wide range of physical parameters such as temperature, light, oxygen content and sound.

Pupils in Year 8 used data-loggers to monitor the changes of state that occurred during the cooling of stearic acid. Cooling curves were plotted as the physical change occurred, enabling pupils to focus on the pattern being shown by the data. Pupils used their knowledge and understanding of particle theory to discuss and explain the patterns they obtained.

Other scientific activities which are enhanced by digital monitoring (data-logging) include:

- the measurement of temperature changes during composting;
- the effect of light levels on the rate of photosynthesis as indicated by evolution of oxygen;
- the use of light intensity to track the progress of a chemical reaction.

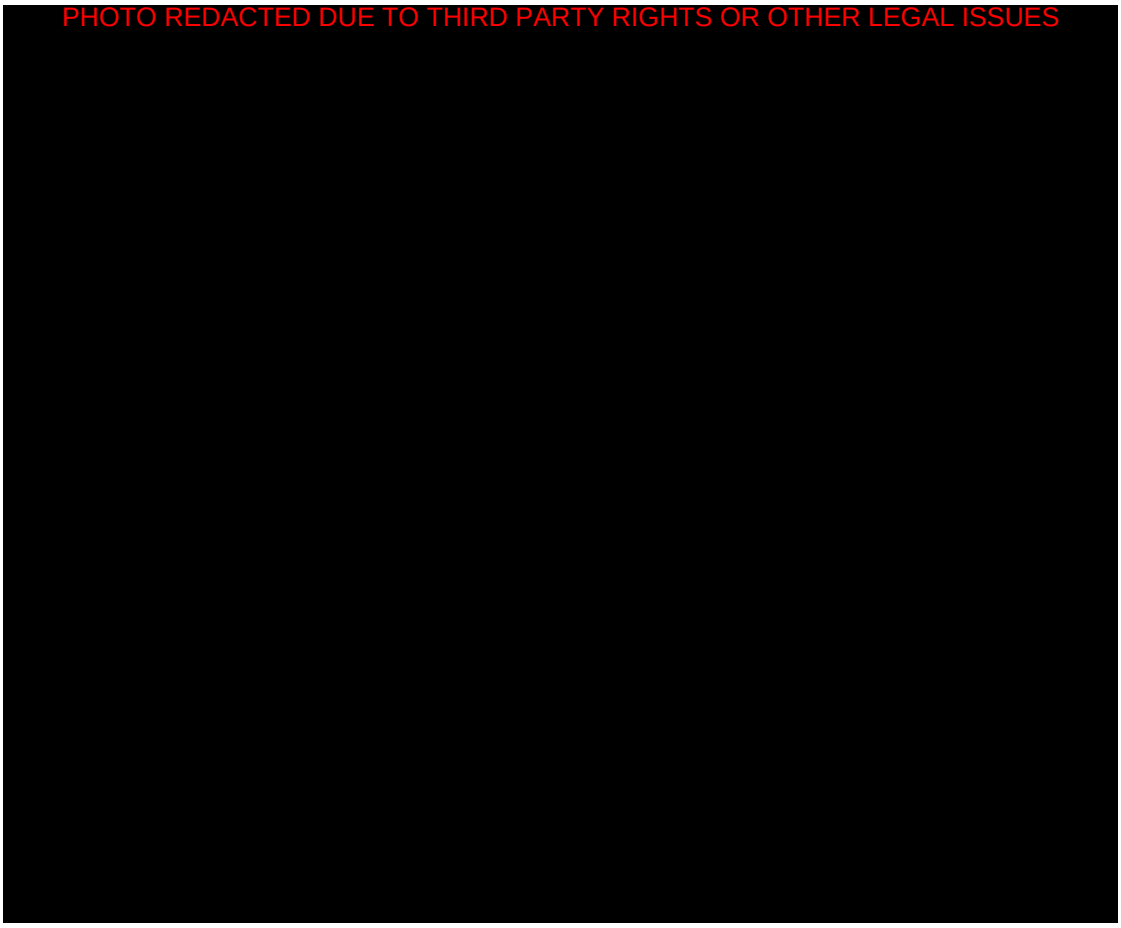
Examples of lessons supplied on the CD-ROM

The CD-ROM includes examples of science lessons in which ICT is used to enhance teaching and learning. These have been chosen to give a flavour of the type of activities in which pupils' ICT capability can be applied and developed within the context of science. They also broadly reflect the ICT key concepts identified on page 15 as being the most appropriate to apply and develop in the science curriculum. The examples offer support for the teaching and learning of science. They also provide opportunities for pupils to apply their own ICT capability to new contexts as well as suggesting ways in which teachers can use ICT as a tool in teaching.

In each example, reference is made to the ICT key concept being applied or developed. In each case, the relevant ICT objectives have been taught before they are applied in the science lesson.

Each example includes a description of the lesson to place it within the context of the curriculum. These identify the science objectives and the expected outcomes, as well as indicating the ICT capability that pupils will be using in the lesson. The lesson outlines that follow are provided as full lesson plans on the accompanying CD-ROM.

Most lessons are supported by resource files and, where appropriate, links are provided to relevant websites for further resources and software downloads.



Lesson 1 Renewable energy resources

Year group: 7

Science objectives covered	Science lesson summary
Pupils will be taught: ■ to identify a range of fuels and explain: – their use as valuable resources; – why conservation of fuels is important in light of the Earth's diminishing resources; ■ that renewable energy resources include wind, waves, running water, sunlight, biomass and some geothermal sources; ■ that renewable energy resources can be used to generate electricity; ■ about some advantages and disadvantages of renewable energy resources.	This lesson is based upon part of the QCA exemplar scheme of work, unit 7I: *Energy resources.* It supports part of the delivery of the section 'What are renewable energy resources?' In the previous lesson, pupils considered the use of fossil fuels, how their supplies might be conserved and why this might be important. **Pupils will be expected to:** ■ locate suitable information by searching a selected website so that they can: – identify the main renewable energy resources; – explain the term 'renewable energy resource'; – describe some of the pros and cons of using different energy resources.

This lesson contributes to the application and development of pupils' capability in the ICT concept of **searching and selecting** by providing a selection of information from which pupils must select the most appropriate, in order to complete the activities.

Lesson 2 Change of state

Year group: 8

Science objectives covered	Science lesson summary
Pupils will be taught: ■ that when a liquid changes to a solid, the temperature remains the same; ■ that a change of state involves energy transfer; ■ to use the particle model of solids, liquids and gases, and energy transfer, to explain what happens when substances change state; ■ to use a range of first-hand experience, secondary sources of information and ICT to collect, store and present information in a variety of ways, including the generation of graphs; ■ to draw conclusions from their own data and describe how their conclusions are consistent with the evidence obtained, using scientific knowledge and understanding to explain them.	This lesson is based upon part of the QCA exemplar scheme of work, unit 8I: *Heating and cooling*. It supports the delivery of the section 'How can we explain change of state?' Earlier in the topic, pupils considered how materials change when they are heated and cooled and how insulation can reduce heat transfer. In the previous lesson, pupils may have considered practical activities and have offered particle model explanations to explain how the materials behaved. **Pupils will be expected to:** ■ describe the pattern shown by a temperature–time graph for a liquid forming into a solid; ■ use a graph of experimental data to measure the melting point; ■ explain change of state in terms of the particle model.
The lesson contributes to the application and development of pupils' capability in the ICT concept of **control and monitoring** by providing an opportunity for pupils to monitor a physical change more effectively through the use of ICT equipment than by traditional methods.	

Lesson 3 How can electricity make a magnet?

Year group: 8

Science objectives covered	Science lesson summary
Pupils will be taught: ■ to use a range of first-hand experience, secondary sources of information and ICT to collect, store and present information in a variety of ways, including the generation of graphs; ■ to use appropriate range, precision and sampling when collecting data during a scientific enquiry, and explain why these and controlled experiments are important; ■ to draw conclusions from their own data and describe how their conclusions are consistent with the evidence obtained, using scientific knowledge and understanding to explain them; ■ how to make and change the strength of an electromagnet.	This lesson is part of the QCA exemplar scheme of work, unit 8J: *Magnets and electromagnets*. It forms part of the delivery of the section 'How can electricity make a magnet?' In the previous lesson, pupils made a simple electromagnet and planned an investigation of the factors which affect the strength of an electromagnet, either during class time or for homework. **Pupils will be expected to:** ■ investigate the factors that affect the strength of an electromagnet, testing their predictions as they do so; ■ use appropriate software to obtain data about the strength of an electromagnet; ■ use a spreadsheet to record and analyse their data, presenting their findings in tables and graphs with trend lines or lines of best fit; ■ draw conclusions that are supported by their data and consider the reliability of the readings they obtained.

This lesson contributes to the application and development of pupils' ICT capability in the concept of **models and modelling** by providing a specific, relevant context in which a computer model (a teaching model) can be used, during an investigation, to gather large amounts of data quickly, and which allows factors to be varied over appropriate ranges. Using a spreadsheet to store and analyse data, from which they draw conclusions for their investigation, enables pupils to apply and develop their capability in the ICT concept **organising and investigating**.

Lesson 4 Photosynthesis investigation

Year group: 9

Science objectives covered	Science lesson summary
Pupils will be taught to: ■ select and use appropriate methods for communicating data; ■ describe patterns in data, use scientific knowledge and understanding to interpret the patterns, make predictions and check reliability; ■ describe how evidence or the quality of the product supports, or does not support, a conclusion in their own and others' enquiries; identify the limitations of data in conclusions.	This lesson is part of the QCA exemplar scheme of work, unit 9C: *Plants and photosynthesis*. It forms part of the delivery of the section 'What is the role of the leaf in photosynthesis?' In the previous lesson, pupils learned that plants need both chlorophyll and light to photosynthesise. The traditional investigation with *Elodea canadensis* is most successful in the late spring and early summer and it can be difficult to obtain reliable results for pupils to analyse. The use of a simulation allows pupils to investigate the effect of a range of variables on oxygen evolution and to collect reasonably reliable data. **Pupils will be expected to:** ■ plan an investigation, based on preliminary trials; ■ obtain evidence and modify their approach in the light of this evidence; ■ carry out a graphical analysis of the results obtained, identify errors and comment on the reliability of the results; ■ establish patterns in terms of how the rate of production of oxygen varies with light intensity; ■ use scientific knowledge to explain whether or not the results support the original prediction; ■ evaluate the procedure followed in the simulation.
This lesson contributes to the application and development of pupils' ICT capability in the concept of **organising and investigating** by providing a specific, relevant context in which relationships between variables can be explored, and conclusions drawn and evaluated.	

Lesson 5 Modelling current and potential difference in simple electrical circuits

Year group: 9

Science objectives covered	Science lesson summary
Pupils will be taught to: ■ develop, from a simple model of energy transfer in electrical circuits, the idea of potential difference in electrical circuits; ■ use the model of energy conservation to explain how: – the potential difference measured across a cell measures how much energy is transferred from the cell to the components in the circuit by the electric current; – the potential difference across each component measures how much energy is transferred from the component to the surroundings; ■ describe patterns in data; use scientific knowledge and understanding to interpret the patterns, make predictions and check reliability.	This lesson is linked to the exemplar QCA scheme of work, unit 9i: *Energy and electricity*. It could form part of the delivery of the section 'How does electricity transfer energy?' and help pupils to review and extend their knowledge of the relationship between electrical current, potential difference and energy in simple electrical circuits. **Pupils will be expected to:** ■ use a simulation to obtain data from simple electrical circuits and test predictions based on the data; ■ identify patterns in the data and use them to develop simple mathematical models that can be used to make predictions; ■ modify the model, based on the results of the tests, to develop a new model to make predictions about a different electrical circuit; ■ use scientific knowledge to explain conditions under which the model is accurate and those under which it is not accurate; ■ understand the relationship between current, potential difference and energy in simple electrical circuits.

The use of the simulation enables pupils to apply and develop their ICT capability in the concept of **models and modelling** by creating a simple formula which they can use as the basis for a model to predict other outcomes. These predictions can then be tested and the model modified accordingly.

Acknowledgements

Thanks are due to INDIGO Visions for kind permission to reproduce lesson 1 from their Enhancing Subject Teaching Using ICT (CPD) materials. The lesson has been extracted from a much broader CPD package offered by INDIGO Visions for teaching and learning, which contains online digital materials, face-to-face support, online mentoring and an online community to share good practice.

Further details can be obtained from the INDIGO Visions website at **www.indigo-visions.co.uk**.

Thanks are due to New Media for kind permission to reproduce lesson 2 from their Enhancing Subject Teaching Using ICT (CPD) materials. The lesson has been extracted from a much broader CPD package offered by New Media for teaching and learning, which contains online digital materials, face-to-face support, online mentoring and an online community to share good practice.

Further details can be obtained from the New Media website at **www.new-media.co.uk/cpd/**.

Further resources

Further resources to support the use of ICT in science can be obtained from these sources.

Key Stage 3 Strategy	**www.standards.dfes.gov.uk/keystage3**
ICT in Schools	**www.dfes.gov.uk/ictinschools/**
QCA	**www.qca.org.uk**
Becta	**www.becta.org.uk** See also Becta's ICT advice website: **ww.ictadvice.org.uk**
Ofsted	**www.ofsted.gov.uk**
National Curriculum in Action	**www.ncaction.org.uk/subjects/ict/inother.htm**
Teachernet	**www.teachernet.gov.uk/teachingandlearning/resourcematerials/**
Virtual Teacher Centre	**http://vtc.ngfl.gov.uk/docserver.php**
National Grid for Learning	**www.ngfl.gov.uk**
Curriculum Online	**www.curriculumonline.gov.uk**
National College for School Leadership	**http://www.ncsl.org.uk/index.cfm**
National Association for Special Educational Needs	**www.nasen.org.uk**

Science

Association for Science Education	**www.ase.org.uk**

5 Next steps

Key questions

This section is intended to support subject leaders when working with their respective departmental teams to move ICT across the curriculum forward. Subject leaders play a crucial role in raising standards by securing and sustaining improvement in the application of ICT capability in all subjects.

Fundamentally, there are four key questions for subject leaders to consider with their subject teams.

- How is use of ICT currently enhancing teaching and learning in science?
- What further opportunities can be exploited?
- What is inhibiting further use of ICT?
- What are the next steps in moving the department forward?

This section offers suggestions for some next steps for you and your department, broadly based around:

- reviewing your current position;
- meeting the requirements for ICT in the science National Curriculum (where appropriate);
- identifying how the ICT National Curriculum is taught in your school;
- applying and developing ICT capability from the ICT National Curriculum;
- using the materials in this ICTAC pack to move forward;
- action planning – making it happen in your department.

Below are some prompts and suggestions for analysing your existing provision, understanding how ICT is taught in your school and identifying potential new opportunities for teaching and learning in your subject.

Reviewing your current position

discussion points

How is ICT being used in your department?

Identify ways in which ICT is currently used in lessons in your department to add value to teaching and learning.

- *What good practice in using ICT currently exists in your department and how does it enhance teaching and learning?*
- *For each of these areas, is ICT being used by pupils, by teachers or by both?*
- *Are all teachers in your department using ICT in lessons in the same way or are individual teachers just using their own ideas?*
- *How can these ideas be shared with other teachers in the department?*

You could consider:

- asking teachers in your department to identify where they use ICT in their lessons and how it impacts on teaching and learning in your subject: use the diagram on page 14 to identify where the use of ICT fits;
- allocating time at departmental meetings to share existing good practice and to look at ways that this could be incorporated or adapted into schemes of work for all teachers in the department;
- setting up peer observation or paired teaching for colleagues to observe each other and assess the value ICT is adding to the lesson – you may find the Key Stage 3 guidance on coaching (included in *Sustaining Improvement: a suite of modules on Coaching, Running networks and Building capacity* (DfES 0565–2003 G)) a useful tool to help you with this;
- using the audit document on the CD-ROM to help analyse your current position – this is adapted from the Key Stage 3 Strategy publication, *Securing improvement – the role of subject leaders* (DfES 0102/2002), which provides further guidance on subject leadership.

ICT in the science National Curriculum

discussion points

Does the use of ICT in your department reflect the National Curriculum requirements for your subject?

Identify any explicit references to the use of ICT in your subject National Curriculum orders and ensure that these areas are already being covered in your department's scheme of work.

- *How do you ensure that all teachers in your department are dealing with the explicit references to ICT in your subject?*
- *How do you monitor, review and evaluate the ICT experiences of all pupils across all classes that are taught by your department?*

You could consider:

- using the National Curriculum orders for science to identify where the programme of study refers to ICT, either specifically or as an example of how a particular aspect of the subject might be taught. The *National Curriculum in Action* website provides a useful starting point for this and outlines statutory requirements and non-statutory opportunities for your subject, see **http://www.ncaction.org.uk /subjects/ict/inother.htm**;
- identifying, within your departmental schemes of work, how and when each of these references will be covered;
- ensuring that you have planned access to the resources you will need by liaising with your ICT coordinator and/or the SMT member with responsibility for ICT across the curriculum;
- sampling pupils' work to ensure consistency across classes; with a focus on the explicit requirements of using ICT in your subject. The Key Stage 3 Strategy publication, *Organising a work sample* (DfES 0390/2003), offers guidance on how you might organise a work-sampling exercise.

Identifying how the ICT National Curriculum is taught in your school

discussion *points*

How is the teaching of the ICT National Curriculum organised in your school?

Identify the aspects of ICT that pupils have been taught in ICT lessons during Years 7, 8 and 9.

- *How is the teaching of the ICT National Curriculum organised in your school?*
- *What ICT capability, through taught ICT lessons, can you reasonably expect pupils to be bringing to your subject lessons in each term?*

You could consider:

- discussing with the school's ICT subject leader how ICT is taught across the key stage in your school, in particular, to find out:
  - the timetable allocation for ICT as a subject in Years 7, 8 and 9 – the Key Stage 3 National Strategy recommends one hour per week in each year for ICT lessons;
  - how the scheme of work for ICT is organised in each term, in each year and what ICT capability you would expect pupils to be bringing to your lessons;
  - the use that is made of the Key Stage 3 Strategy's *ICT sample teaching units* – the Strategy has produced detailed lesson plans with accompanying resources for Years 7 and 8, and case studies for Year 9, based on the QCA Key Stage 3 scheme of work.

Applying and developing ICT capability taught in ICT lessons

discussion *points*

Does the use of ICT in your department reflect the National Curriculum requirement to give pupils opportunities to apply and develop their ICT capability?

Identify where your current scheme of work gives pupils opportunities to apply and develop their ICT capability at a level appropriate to their experience.

- *Are all teachers in your department fully aware of the breadth of ICT capability that pupils are taught in ICT?*
- *Which parts of the ICT National Curriculum are particularly significant for your subject and give pupils potential opportunities to apply and develop their ICT capability?*
- *Are there implications for training for teachers in your department?*
- *Does the scheduling of your subject scheme of work and the ICT scheme of work provide a coherent way forward for pupils' use of ICT?*

You could consider:

- inviting the ICT subject leader to a departmental meeting to explain the breadth of ICT capability that pupils are taught in the ICT National Curriculum. You may find Appendix 2 helpful for the discussion, in that it provides an overview of how the Key Stage 3 programme of study could be broken down into yearly teaching objectives. This appendix is extracted from the Key Stage 3 National Strategy publication, *Framework for teaching ICT capability: Years 7, 8 and 9* (DfES 0321/2002), which also provides further guidance on teaching ICT as a subject;
- identifying areas for staff development, either for individual teachers or the whole department and working with the ICT subject leader and the LEA to establish sources of support;
- discussing with the ICT subject leader possible changes to the schedule of the schemes of work to ensure that, in subject lessons, pupils are building on ICT that has already been taught;
- working with the school's ICT coordinator to identify how your department contributes to the whole-school policy of ICT across the curriculum;
- discussing with other subject leaders in the school how they give pupils opportunities to apply and develop ICT capability in their respective subjects.

Using the resources in the ICTAC pack to move forward

The pack comprises five components:

1 ***ICT in …* series guides (this publication)**
The guides consider how subjects can build on the ICT capability taught in ICT lessons, in this case, to add value to teaching and learning in science.

2 **Video on CD-ROM**
The video on the CD-ROM gives an example of how one subject leader has tackled the use of ICT in science.

3 **Examples of lessons on CD-ROM**
The examples on the CD-ROM provide lesson plans and resources to demonstrate some ways that ICT could be applied and developed in science.

4 **Posters**
The poster gives a pictorial representation of the ICT key concepts and examples of how some of these could be relevant to teaching and learning in science.

5 Management guide

A guide for school leaders, in particular, the senior member of staff with overall responsibility for ICT across the curriculum. It outlines the need for a whole-school approach to ICT across the curriculum and offers guidance on how this may be achieved.

Moving forward

***discussion** points*

How can you move forward, using ICT to add value to teaching and learning in science?

Use the materials provided in the ICTAC pack to identify new opportunities for pupils to apply and develop their ICT capability.

- *Which of the ICT key concepts are particularly relevant to your subject? Which aspects of ICT capability can be applied and developed in your subject?*
- *What new opportunities are there for adding real value to teaching and learning in your subject by exploiting the ICT capability that pupils are bringing to your lessons?*
- *In the light of pupils' increasing ICT capability, how do you ensure that the most effective use is made of ICT?*
- *How does the work on ICT across the curriculum in your department fit with the whole-school policy of ICT across the curriculum?*

You could consider:

- using the overview of the nine ICT concepts in Appendix 1 of this *ICT in science* guide to raise your awareness of the ICT that is taught to pupils, and the level of ICT capability that pupils will be bringing to your lessons that you can apply and develop. The nine ICT key concepts provide a way of considering the breadth of ICT capability that pupils will bring to your lessons. Some key concepts will be more relevant than others to your subject and some may well overlap. The important point is that the overview provides a basis for analysing current provision and potential new opportunities;
- using the ICT key concepts described in section 3 of this booklet, and on the accompanying posters, to identify new opportunities for your subject. Examples of how some of these key concepts are significant for science are given to provide stimuli for analysing your current schemes of work for additional opportunities;
- using the examples of lessons, provided on the CD-ROMs, to provoke thought and compare with your current practice. Overviews of each of these lessons are provided in section 4 of this booklet;
- viewing the video clip on the CD-ROM to consider how one science department is going about embedding ICT in their subject;
- using the additional resources provided in section 4 of this guide and on the CD-ROM to identify further sources of support and guidance;
- if this is part of a wider-school day on ICT across the curriculum, viewing the video clip on the Management Guide CD-ROM, which considers the critical roles of headteacher, SMT with responsibility for ICT, ICT subject leader, ICT coordinator and other subject leaders in moving ICT across the curriculum forward in the school.

If your school has selected ICT across the curriculum as its whole-school priority, the LEA's ICTAC lead consultant will be able to offer further support and guidance on using the materials in this ICTAC pack.

Working with the ICTAC pack

Action-planning – making it happen in your department

Clearly schools will be at different stages of development with ICT across the curriculum. Departments within individual schools will also be at different stages. This ICTAC pack is designed to be used flexibly, for example:

- as part of a whole-school focus on ICT across the curriculum, supported by the LEA's lead ICTAC consultant;
- as an individual department working within a school;
- as a group of departments within a school;
- as a group of subject departments across schools.

Whatever the scenario, subject leaders should define clear priorities, using the materials in this pack. Consider:

- reviewing the current position;
- using the materials in this ICTAC pack to provoke thought and help identify possible routes forward;
- looking at schemes of work and identifying changes that would have minimal resourcing implications for staff and equipment;
- identifying changes that would have more substantial implications;
- how the work on ICT across the curriculum in your department is located within the whole-school policy for ICT across the curriculum;
- liaising with other key players in the school, in particular, the ICT subject leader and ICT coordinator and/or senior teacher with responsibility for ICT across the curriculum;
- liaising with the LEA for sources of support, in particular, the LEA's lead ICTAC consultant.

Appendices

Appendix 1

Key concepts

Finding things out

The theme **Finding things out** is concerned not only with finding information from a wide range of sources but also with recognising that the user must judge the quality of content found.

Pupils are taught to make judgements about the validity, reliability and bias of various **data and information sources**, and to select information relevant to a task, using, for example, CD-ROMs or the Internet. They are taught that the way in which different types of information are combined conveys meaning. For example, pupils recognise that the arrangement of text, graphics, and numeric data in an advertisement is intended to persuade us to buy a product.

When **searching and selecting**, pupils are taught to use search engines to find appropriate information, to refine their searches, to make them more effective and to select relevant information by reference to its origin and quality. For example, a pupil searching the Internet for information about global warming might select the data found on a website with a .org or .gov suffix because it should be more reliable.

When **organising and investigating**, pupils are taught to retrieve and collect information for a specific purpose or task. They process the data in various ways to find something out, draw conclusions or answer hypotheses. They are able to present their findings effectively. For example, pupils may develop a hypothesis about the effects of a local building project. To test this hypothesis they would create a questionnaire to collect and record people's attitudes, process the data in a spreadsheet or database and use their analysis to support or refute their hypothesis, finally using graphs to present their findings.

Developing ideas and making things happen

Developing ideas and making things happen is concerned with using ICT to process, develop or display information efficiently.

Pupils are taught to **analyse** problems, breaking them down into component parts, and to **automate processes** to increase their speed and accuracy. For example, pupils may develop their understanding of efficiency by using master pages in publications to explore a range of possibilities before making a decision.

Pupils are taught that they can use **models and modelling** to represent a situation or process on screen. They explore patterns and relationships by changing variables and rules and can use this technique to answer 'What if … ?' questions. For example, pupils may explore a spreadsheet model of the relative costs of running a mobile phone by changing the number of minutes used per month (changing variables) to see what the phone would cost if … . They may then develop the model by including the number of free text messages (changing rules).

Pupils are taught to develop computer-based systems to **control and monitor** situations. They analyse the problem and design, create, test and refine a solution. For example, in a science experiment pupils may develop a system to measure temperature, light and humidity, using a range of sensors incorporating a subroutine for each sensor, with appropriate sampling rates, and triggering an alarm when a condition is met.

Exchanging and sharing information

This theme relates to the process of communication. Pupils are taught to recognise common forms and conventions used in communications and to use this knowledge to present information appropriately to a specified audience.

When **exchanging and sharing information**, pupils are taught to consider **fitness for purpose**. They review and evaluate the effectiveness of their work and are able to justify the choices they have made. They are able to use this critical evaluation to develop and improve their **presentation** of information, **refining** it for the purpose and audience. For example, pupils may use digital video to create an advertisement for overseas visitors to their locality. They may refine their work further by devising criteria drawn from an analysis of existing TV adverts, during which they identify the common forms and conventions.

They are taught to use ICT to **communicate** effectively with wider and remote audiences. For example, pupils may use e-mail or online questionnaires to gather information from pupils in other countries, recognising and understanding the technical issues involved and the rules governing such communications.

Appendix 2

Yearly teaching objectives for ICT

Year 7 teaching objectives

Finding things out

Using data and information sources

- Understand that different forms of information – text, graphics, sound, numeric data and symbols – can be combined to create meaning and impact.
- Identify the purpose of an information source (e.g. to present facts or opinions, to advertise, publicise or entertain) and whether it is likely to be biased.
- Identify what information is relevant to a task.
- Understand how someone using an information source could be misled by missing or inaccurate information.

Searching and selecting

- Search a variety of sources for information relevant to a task (e.g. using indexes, search techniques, navigational structures and engines).
- Narrow down a search to achieve more relevant results.
- Assess the value of information from various sources to a particular task.
- Acknowledge sources of information used.

Organising and investigating

- In an investigation:
  - design and use an appropriate data handling structure to answer questions and draw conclusions;
  - design a questionnaire or data collection sheet to provide relevant data;
  - check data efficiently for errors;
  - investigate relationships between variables;
  - use software to represent data in simple graphs, charts or tables, justifying the choice of representation;
  - derive new information from data, e.g. averages, probabilities;
  - check whether conclusions are plausible;
  - review and amend the structure and its data to answer further questions.

Developing ideas and making things happen

Analysing and automating processes

- Use automated processes to increase efficiency (e.g. templates, master pages).
- Represent simple processes as diagrams, showing:
  - how a task can be broken down into smaller ones;
  - the sequence of operations, and any conditions or decisions that affect it;
  - the initial information needed (e.g. room temperature, prices of items).

Models and modelling

- Use software to investigate and amend a simple model by:
  - formatting and labelling data appropriately (e.g. formatting cells to display currency);
  - entering rules or formulae and checking their appropriateness and accurate working;
  - explaining the rules governing a model;
  - predicting the effects of changing variables or rules.
- Test whether a simple model operates satisfactorily.

Control and monitoring

- Implement a system to carry out a simple control task, including some that involve sensed physical data, by:
  - compiling sets of instructions, identifying those which can be grouped to form procedures or loops;
  - testing and refining the instructions.

Exchanging and sharing information

Fitness for purpose

- Recognise common forms and conventions used in communications and how these address audience needs (e.g. columns of text in newspapers, graphics and enlarged print in posters, hyperlinks on websites).
- Apply understanding of common forms and conventions to own ICT work.
- Use given criteria to evaluate the effectiveness of own and others' publications and presentations.

Refining and presenting information

- Plan and design the presentation of information in digital media, taking account of the purpose of the presentation and intended audience.
- Use ICT to draft and refine a presentation, including:
  - capturing still and moving images and sound (e.g. using a scanner, digital camera, microphone);
  - reorganising, developing and combining information, including text, images and sound, using the simple editing functions of common applications;
  - importing and exporting data and information in appropriate formats.

Communicating

- Use e-mail securely and efficiently for short messages and supporting material.
- Know how to protect personal details and why this is important.

NOTE: Objectives highlighted in colour are related to reviewing, modifying and evaluating work as it progresses.

Year 8 teaching objectives

Finding things out

Using data and information sources

- Understand how the content and style of an information source affect its suitability for particular purposes, by considering:
  - its mix of fact, opinion and material designed to advertise, publicise or entertain;
  - the viewpoints it offers;
  - the clarity, accessibility and plausibility of the material.
- Devise and apply criteria to evaluate how well various information sources will support a task.
- Justify the use of particular information sources to support an investigation or presentation.

Searching and selecting

- Extend and refine search methods to be more efficient (e.g. using synonyms and AND, OR, NOT).
- Explain the advantages of the methods used by different search engines and programs to search for data in various formats.

Organising and investigating

- In an investigation:
  - use software options and formats to store, retrieve and present electronic material efficiently;
  - explore and interpret collected data in order to draw conclusions;
  - assess the consistency of conclusions with other evidence.
- Understand:
  - how data collection and storage are automated in commerce and some public services;
  - the impact of electronic databases on commercial practice and society;
  - potential misuse of personal data.

Developing ideas and making things happen

Analysing and automating processes

- Automate simple processes by:
  - creating templates;
  - creating simple software routines (e.g. style sheets, web queries, control techniques on web pages).
- Consider the benefits and drawbacks of using ICT to automate processes (e.g. using wizards, templates).
- Represent simple design specifications as diagrams.

Models and modelling

- Develop ICT-based models and test predictions by changing variables and rules.
- Draw and explain conclusions (e.g. 'the best value for money is obtained when …').
- Review and modify ICT models to improve their accuracy and extend their scope (e.g. by introducing different or new variables and producing further outcomes).

Control and monitoring

- Develop and test a system to monitor and control events by:
  - using sensors efficiently;
  - developing, testing and refining efficient sequences of instructions and procedures;
  - assessing the effects of sampling and transmission rates on the accuracy of data from sensors.
- Understand how control and monitoring has affected commercial and industrial processes (e.g. telecommunication, health and transport services).

Exchanging and sharing information

Fitness for purpose

- Recognise how different media and presentation techniques convey similar content in ways that have different impacts.
- Understand that an effective presentation or publication will address audience expectations and needs (e.g. the audience's levels of literacy, familiarity with a topic).
- Devise criteria to evaluate the effectiveness of own and others' publications and presentations, and use the criteria to make refinements.

Refining and presenting information

- Plan and design presentations and publications, showing how account has been taken of:
  - audience expectations and needs;
  - the ICT and media facilities available.
- Use a range of ICT tools efficiently to combine, refine and present information by:
  - extracting, combining and modifying relevant information for specific purposes;
  - structuring a publication or presentation (e.g. using document styles, templates, time lines in sound and video editing, navigational structures in web media).

Communicating

- Understand some of the technical issues involved in efficient electronic communications (e.g. speed and bandwidth, size and type of file, features of different browsers and mail software).
- Use ICT effectively to adapt material for publication to wider or remote audiences (e.g. as web articles or sites).

NOTE: Objectives highlighted in colour are related to reviewing, modifying and evaluating work as it progresses.

Year 9 teaching objectives

Finding things out

Using data and information sources

- Select information sources and data systematically for an identified purpose by:
  - judging the reliability of the information sources;
  - identifying possible bias due to sampling methods;
  - collecting valid, accurate data efficiently;
  - recognising potential misuse of collected data.

Searching and selecting

- As part of a study, analyse high-volume quantitative and qualitative data systematically by:
  - exploring the data to form and test hypotheses;
  - identifying correlations between variables;
  - drawing valid conclusions and making predictions;
  - reviewing the process of analysis and the plausibility of the predictions or conclusions.

Organising and investigating

- Construct, test and document the development of a database system which shows:
  - a design specification;
  - appropriate means of data input and validation;
  - systematic testing of processes and reports;
  - evaluation of the system's performance and suggested modifications.

Developing ideas and making things happen

Analysing and automating processes

- Automate ICT processes (e.g. use software to merge mail, create macros in an application program).
- Represent a system in a diagram, identifying all its parts, including inputs, outputs and the processes used (e.g. to validate data).

Models and modelling

- Design and create ICT-based models, testing and refining rules or procedures.
- Test hypotheses and predictions using models, comparing their behaviour with information from other sources.

Control and monitoring

- Use ICT to build and test an efficient system to monitor and control events, including:
  - testing all elements of the system using appropriate test data;
  - evaluating the system's performance;
  - annotating work to highlight processes and justify decisions.
- Review and modify own or others' monitoring and control systems to improve efficiency (e.g. use more efficient procedures, reduce the number of instructions or procedures, add an element of feedback).

Exchanging and sharing information

Fitness for purpose

- Produce high quality ICT-based presentations by:
  - creating clear presentations, sensitive to audience needs;
  - justifying the choice of form, style and content.
- Use knowledge of publications and media forms to devise criteria to assess the quality and impact of multimedia communications and presentations, and apply the criteria to develop and refine own work.

Refining and presenting information

- Use a wide range of ICT independently and efficiently to combine, refine, interpret and present information by:
  - structuring, refining and synthesising information from a range of sources;
  - selecting and using software effectively, justifying the choices made.

Communicating

- Apply knowledge of the technical issues involved to communicate information efficiently (e.g. choose suitable file types to speed up transfer, use mail lists to speed up communication, use website tagging and hyperlinks to speed up searching).
- Understand the advantages, dangers and moral issues in using ICT to manipulate and present information to large unknown audiences (e.g. issues of ownership, quality control, exclusion, impact on particular communities).

NOTE: Objectives highlighted in colour are related to reviewing, modifying and evaluating work as it progresses.

Appendix 3
End of Key Stage 2 expectations

From Key Stage 2 to Key Stage 3

This appendix describes what most pupils should have learned in ICT by the end of Key Stage 2, particularly those aspects that relate to the yearly objectives in Key Stage 3.

Finding things out

By the end of Year 6, most pupils should be able to:

- identify the information they need to complete a simple task or solve a simple problem;
- use simple search techniques, including indexes and lists of contents, to find information;
- prepare information for use in a task by downloading relevant pieces or collecting them from various sources;
- classify information for use in a database and understand how a suitable structure is created;
- recognise different types of information such as text, numbers, graphics;
- enter data into a database, search it and present data in simple tables and graphs;
- check that information is accurate and reasonable;
- discuss what might happen if information is entered into the computer incorrectly or not downloaded completely.

Developing ideas and making things happen

By the end of Year 6, most pupils should be able to:

- combine text, graphics and sound to develop and present their ideas;
- reorganise information for a particular task or problem;
- create, test and refine a simple sequence of instructions to control events or make things happen;
- use datalogging equipment to monitor changes, for example, in light, temperature or sound;
- use simple spreadsheet models to explore the effect of changing variables and answer straightforward questions;
- identify patterns revealed by simple models or simulations.

Exchanging and sharing information

By the end of Year 6, most pupils should be able to:

- use e-mail;
- use software to create stories, animations, presentations, displays and posters;
- consider the needs of different audiences, such as parents, peer groups, younger or older pupils;
- recognise the need for quality and accuracy in their presentations of work and ideas;
- work in groups to solve problems and complete tasks.

Reviewing, modifying and evaluating work as it progresses

By the end of Year 6, most pupils should be able to:

- review what they have done and consider how they might improve their work;
- evaluate other people's work and get ideas for their own;
- describe their use of ICT and how they might have completed a task using other methods;
- compare their use of ICT with other people's;
- recognise the benefits of using ICT for particular tasks;
- describe some uses of ICT outside school and the impact it might have on people at work and at home.

Copies of this document may be available from:

DfES Publications
Tel: 0845 60 222 60
Fax: 0845 60 333 60
Textphone: 0845 60 555 60
e-mail: dfes@prolog.uk.com

Ref: DfES 0178-2004 G

Produced by the
Department for Education and Skills

www.dfes.gov.uk

If this is not available in hard copy it can be downloaded from:

www.standards.dfes.gov.uk

department for
education and skills
creating opportunity, releasing potential, achieving excellence

Raising Standards
Standards and Effectiveness Unit

INVESTOR IN PEOPLE

OUP 09-2004