ICT across the curriculum

ICT in mathematics

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Department for Education

Key Stage 3
National Strategy

ICT across the curriculum

ICT in mathematics

department for education and skills

creating opportunity, releasing potential, achieving excellence

Key Stage 3
National Strategy

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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 mathematics* guide

This *ICT in mathematics* 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 mathematics;
- analyse the opportunities that exist in mathematics for developing and applying pupils' ICT capability;
- consider how ICT can add value to the teaching and learning of mathematics.

> 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)*

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 mathematics, where ICT is used as a vehicle to support achievement of those objectives and to enhance teaching and learning in mathematics.

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 mathematics lessons with expectations about how they might apply ICT to move their own learning forward. Mathematics 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 mathematics. Consequently, the focus of the lesson remains firmly rooted in mathematics 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 mathematics 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 mathematics and should not be seen simply as a bolt-on. It needs to be carefully integrated into mathematics 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 mathematics 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 mathematics 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 page 9.

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

- use their ICT capability to assist and progress their learning in mathematics;
- 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.

ICT capability	Apply and develop ICT capability

ICT – the subject
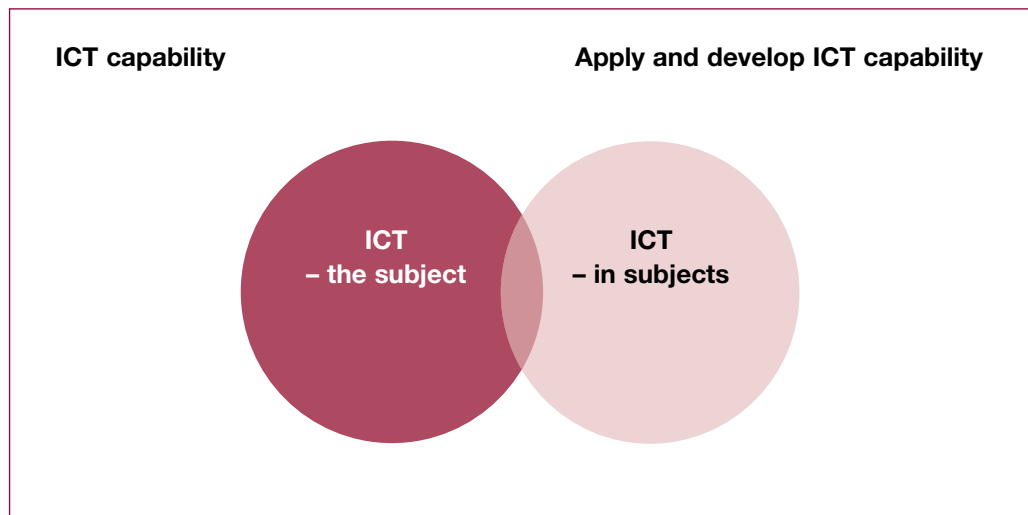
ICT – in subjects

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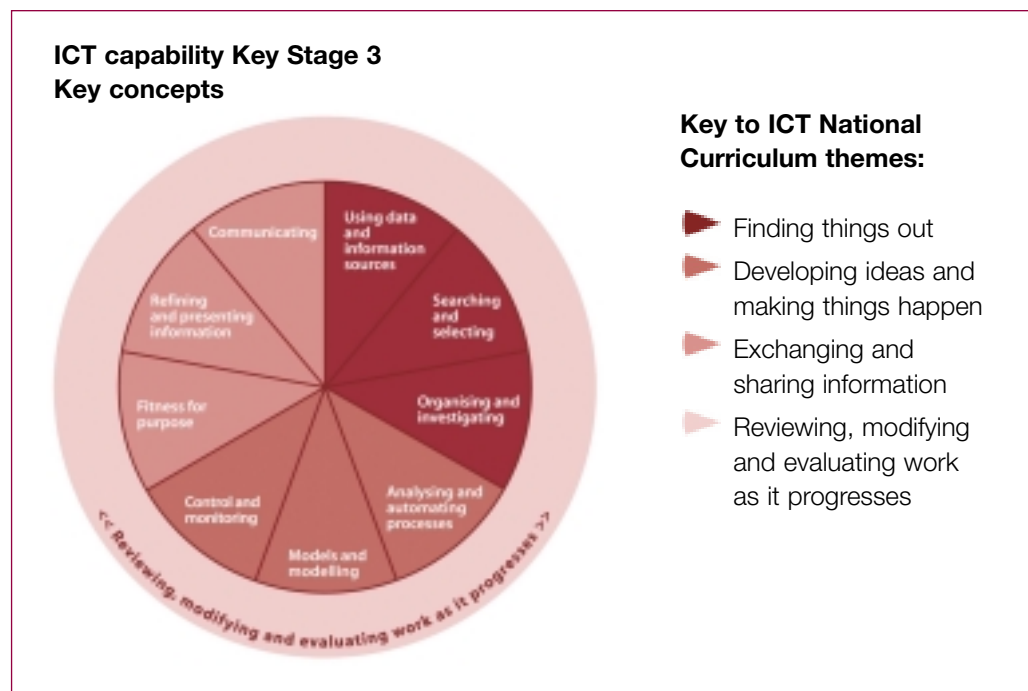
The diagram above shows the nine key concepts of ICT capability. Further guidance about each of these concepts can be found in Appendix 1.

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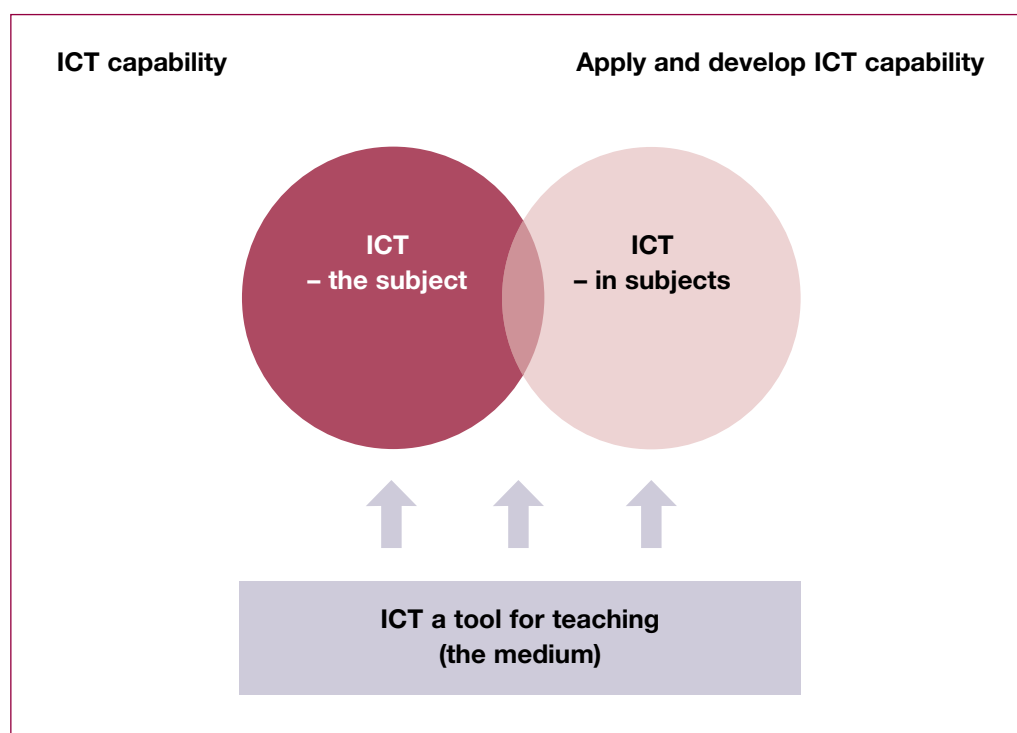
Clearly elements of the model will overlap and impinge on each other. For whole-school policies for ICT across the curriculum the challenge is to make the most purposeful use of the available resources across all teaching and learning. Opportunities to embed ICT suitably in subject-teaching need to be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

The diagram introduced on page 11 has been expanded to highlight some of the ICT key concepts that are particularly significant for mathematics. These are expanded further on the *ICT in mathematics* poster (DfES 0200–2004 G) that accompanies this pack.
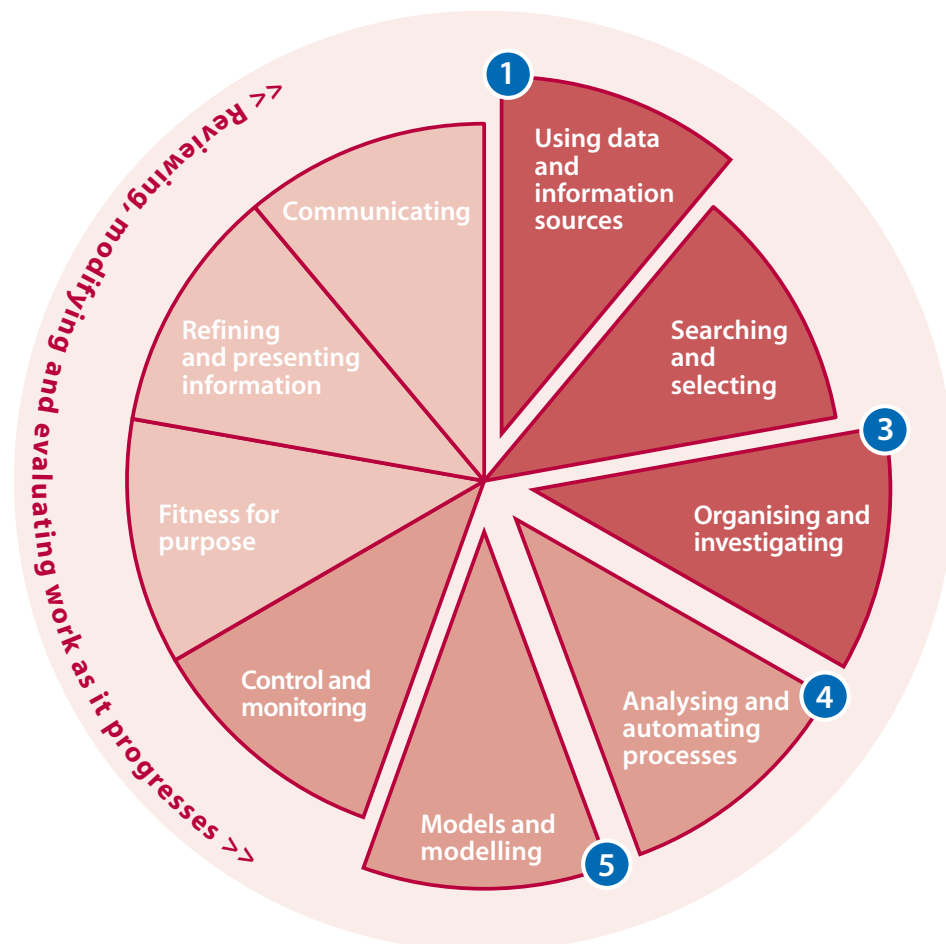
Key to ICT National Curriculum themes:

▶ 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 mathematics*

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 mathematics, some are more significant than others. The four key concepts, highlighted in the diagram, that are particularly significant for mathematics are:

- using data and information sources;
- organising and investigating;
- analysing and automating processes;
- models and modelling.

Other ICT key concepts could also be applied and developed in mathematics. For example, the key concept of **control and monitoring** could be developed in using a motion sensor, for pupils to 'walk through' graphs of specific mathematical functions, such as $t = 2d$ or $t = d^2$.

How can the use of ICT raise standards in mathematics?

ICT can be used as a tool:

- to support teachers in teaching an objective more effectively, in improving lesson design and improving teaching and learning;
- to enable pupils to engage with learning and to be motivated to improve their learning;
- to enable pupils to access geometrical, graphical and statistical ideas dynamically and so to make connections in their learning;
- to build pupils' confidence in their mathematical abilities by testing their conjectures, learning from feedback and using reasoning to modify their solutions.

The Strategy web-based document, *Integrating ICT into mathematics in Key Stage 3* (**www.standards.dfes.gov.uk/keystage3**), includes some useful guidance on selecting, organising and using ICT for the teaching and learning of mathematics. Pupils in mathematics most benefit from the use of ICT in areas such as:

- the teacher using an interactive or electronic whiteboard for starters and plenaries;
- the teacher using an electronic whiteboard for interactive teaching in the main part of the lesson;
- using generic software such as databases or spreadsheets as a means of making sense of data;
- using content-free, mathematics-specific software on computers or graphical calculators to aid visualisation and help make connections in algebra and geometry;
- using simple programming languages, such as LOGO, to build increasingly complex mathematical models and relationships in shape and space, number and algebra;
- using content-specific software, usually targeting specific mathematical skills;
- processing and interpreting experimental information from data-loggers;
- using information resources such as the Internet, CD-ROMs or data files.

Planning and progression

Teachers should expect pupils in any given year to have been taught all or most of the ICT Framework objectives from the previous year. Teachers of mathematics 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 mathematics, teachers should:

■ plan the use of ICT by pupils in collaboration with the ICT department to ensure that pupils have appropriate ICT skills;

■ be sure that ICT resources are available for the lesson;

■ analyse how to build on prior learning in mathematics and ICT to inform planning of schemes of work and design of lessons.

It is important to plan for a range of uses of ICT, to ensure that pupils' capability is developed and consolidated as they progress, both in mathematics and the use of ICT. In particular, teachers should, in most circumstances, plan to use ICT in mathematics 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 mathematics;

■ as pupils' ICT capability increases they are given further opportunities to apply and develop aspects of that capability in mathematics lessons.

It may be appropriate to use low-level ICT skills to enhance learning in mathematics, but pupils should also be given opportunities to apply higher-order skills. This should enable pupils to enhance their learning in mathematics further, as well as to develop their capability in ICT. 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 the capabilities of pupils competent in ICT will enable teachers to plan lessons that use and apply ICT to help challenge and motivate pupils of all attainment levels. It is expected that:

■ Year 6 ICT capability will support Year 7 work in mathematics;

■ Year 7 ICT capability will support later Year 7 and Year 8 work in mathematics;

■ Year 8 ICT capability will support later Year 8 and Year 9 work in mathematics;

■ Year 9 ICT capability will support both later Year 9 work in mathematics 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 mathematics lessons

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

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

■ the ICT is adding value to the lesson:
  – Would the mathematics 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, often in the plenary, for pupils to communicate their understanding of how ICT has contributed to their learning in mathematics;

■ 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 mathematics.

This section identifies some of the opportunities for applying and developing pupils' capability in ICT that can be built into medium- and short-term planning in mathematics. It considers ICT key concepts that offer significant opportunities to enhance pupils' learning in mathematics 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.

Using data and information sources

ICT can be used to give access to large quantities of data and provides the tools to represent it in a variety of ways. Using these opportunities can help pupils to put forward hypotheses, represent and interpret data and to discuss ways that data may be distorted through misrepresentation.

The ICT key concept of **using data and information sources** relates to the strand of handling data in mathematics in which pupils specify a problem, plan and collect data. It impacts on two of the distinctive features of handling data outlined in the *Framework for teaching mathematics: Years 7, 8 and 9* (DfES 0020/2001)*:*

■ basing work on *purposeful enquiry*, using situations of interest and relevance to pupils and making appropriate links to other subjects;

■ using ICT as a powerful source of data, and as a means of processing data and simulating situations.

Page 18 of the *Guide to the Framework for teaching mathematics: Years 7, 8 and 9* (DfES 0020/2001) suggests:

Give pupils experience of collecting and using primary data from, for example, questionnaires or results of an experiment, and secondary data from published sources, including reference materials, ICT databases and the Internet. Plan carefully how to balance and use the various sources across the key stage.

In choosing how to go about a problem that can be addressed by statistical methods, pupils will take decisions about the value of ICT resources available. These may include equipment, such as temperature sensors, for gathering first-hand data, or secondary sources, such as databases or websites, that will provide them with evidence to support different lines of enquiry.

> When working on Handling data 2, at the beginning of the spring term, Year 7 pupils used some questions from the *Census at school* database as a basis for a survey of their own class. They discussed possible groupings for their data before designing a data collection sheet. They inserted their own results into a spreadsheet and discussed how they might represent them. They then selected some national data from different regions to compare with that from their own class. During the plenary, pupils commented that a very low frequency for journey times to school may be insufficient as journey times in bad weather, especially in winter, may be much longer than in dry conditions during summer. The use of ICT reinforced the skills of using a spreadsheet, enabling them to group, record, sort, find averages and represent their own primary data. The *Census at school* database provided a useful source of secondary data for comparison.

Groups in a Year 8 class posed their own comparative questions such as, *In urban schools, do more boys than girls cycle to school?* or *Are Manchester United supported by more pupils in rural schools than in urban schools?* After using the data from the *Census at school* site to answer their question, they then exchanged questions with another group. When both had responded to the questions, they met to compare methods and conclusions. The use of ICT gave them access to a large database, and enabled them to consider questions that were of interest to them. Their mathematics benefited as they made the link between proportions in data and representing them in pie charts.

In mathematics, Year 7 pupils build upon the ICT skills they developed in Key Stage 2 as they use information from data sources, including websites, databases, spreadsheets and CD-ROMs, to make decisions about the relevance of particular information and to make and test hypotheses. During Year 8, they plan and organise the means of gathering data and discuss how to use information. They make decisions about relevance and about the appropriateness of sample sizes. By the end of Year 9 they undertake purposeful enquiry, identifying possible sources of data and, in some cases, sources of bias.

Within mathematics lessons, pupils are likely to cover aspects of these objectives when using ICT as a source of secondary data or as a data-logging or collection tool. As pupils progress through the key stage, the ICT objectives diverge from those in mathematics, focusing increasingly on the use and evaluation of more sophisticated ICT skills, which may be beyond requirements of Key Stage 3 mathematics.

Organising and investigating

Use of ICT allows pupils to sort and represent data efficiently and effectively. It enables them to solve mathematical problems and use statistical investigations using their own data as well as that collected by others.

The **organising and investigating** strand of ICT provides a background for the ways in which ICT links directly into the strands of handling data in mathematics.

- In specifying a problem, planning and collecting data, where ICT sources are being used for the process of data collection, the links will be in the use of appropriate data, connected to outcomes, and the process of organising how the data will be collected.
- In processing and representing data, using ICT as appropriate, the choice, design and use of graphs, charts and tables, and their suitability for checking hypotheses, are central to this strand of ICT.
- When interpreting and discussing results, mathematics and ICT both require pupils to evaluate conclusions drawn and methods used.

The use of ICT supports pupils in constructing questionnaires and surveys in mathematics, recording results and representing data in ways that support accurate interpretation.

In mathematics, Year 7 pupils plan and organise the means of gathering data, and use ICT to represent the results of a statistical enquiry or to calculate averages and measures of spread for the purpose of interpreting data. Over the key stage, the use of suitable ICT packages in mathematics can support pupils' increasing technical competence and develop their skills in questionnaire design and the use of data sources, identifying information needed to pursue a particular line of enquiry.

In mathematics, pupils should be given opportunities to draw inferences and conclusions from data. They compare and evaluate their outcomes in relation to the original context of the problem and can assess the value of data sources used. Teachers' use of the online Strategy materials, *Interacting with mathematics in Key Stage 3: Handling data*, will provide pupils with opportunities to decide the most effective means of representing the results of a statistical enquiry in order to draw conclusions.

Year 8 pupils worked in pairs on the *Comparing groups* activity on the CD-ROM from the Key Stage 3 National Strategy pack, *Interacting with mathematics in Key Stage 3: Securing progression in handling data* (DfES 0658–2003 G). They enjoyed discussing similarities and differences in height, weight, age and income of four groups: England footballers, orphaned children, Sumo wrestlers and Second World War veterans. They used terms such as *mode*, *mean*, *median* and *range*, and discussed what changes, shown in animations, would occur in any of these measures if, for example, a Sumo wrestler changed places with one of the veterans, or if David Beckham changed places with one of the orphans. The work stressed the impact on the different measures of average of exceptional values.

Using the *Population and development* database, Year 9 pupils looked at apparent correlation between life expectancy and longitude in European countries. By exploring the data for other continents they were able to discount the original conjecture that there was correlation between the two, so they explored other data from the site to establish some closer global connections to life expectancy. In doing so they discussed appropriateness of different charts and tables, including scatter graphs for comparing numeric data.

Another Year 9 class used the *Population and development* database to investigate the gulf between rich and poor countries. They used their ICT skills to explore trends in data, related to aspects such as GNP per head of population, life expectancy, access to safe water, number of doctors per 100 000 people and infant mortality rates in different countries. They used a range of graphs to make connections between distributions, and began to discuss the validity of connections made and their perceptions of strong and weak correlations in the data. Pupils commented that exploring the database had made them much more aware of the range of problems affecting the lives of people in some developing countries.

Analysing and automating processes

Using ICT allows pupils to use automated processes to increase efficiency and to create simple software routines to aid the exploration of a mathematical situation. They can undertake deeper and more effective analysis of the mathematics, using ICT.

Pupils in Year 9 may choose to create macros in spreadsheets or may use other automating functions, including nesting procedures in LOGO, to explore a range of mathematical situations. Use of LOGO can be beneficial to pupils in each year of the key stage, especially as it is easily accessible and combines aspects of geometrical reasoning with using and applying mathematics to solve problems.

When using graphical calculators or graph-plotters, the idea of a 'variable constant' is a valuable way of exploring generality, for example, in Year 7, letting m take a range of values when exploring functions of the form $y = mx$.

Year 7 pupils targeting level 4 were introduced to LOGO, and wrote programs to draw a square, an equilateral triangle and an isosceles right-angled triangle, using *repeat*. They were able to explain why the programs they had written worked.

See *Key Stage 3 National Strategy, Targeting level 4 in mathematics: Shape, space and measures 4, lesson S4.1 (DfES 0085/2003).*

Year 8 pupils devised LOGO procedures to construct specific quadrilaterals, using known properties. They were able to use *repeat 2 […]* for parallelograms, rhombi and rectangles, but not for kites and trapezia. Through teacher questioning they recognised that these shapes had order 2 rotational symmetry. This led them on to deducing other properties of these shapes, such as opposite angles being equal, diagonals bisecting each other.

Year 9 pupils devised and were able to explain LOGO procedures, including *repeat …* for constructing regular polygons. Through discussion, they were able to make connections between the number of sides of the polygon, its symmetries and the sizes of its interior and exterior angles so that, given any one of these, they were quickly able to calculate the other two.

Year 9 pupils adapted a LOGO procedure that they had written for a regular octagon to produce a tessellation of regular octagons and squares. They were then able to adapt this procedure to produce other semi-regular tessellations, for example, regular dodecagons and equilateral triangles.

Year 7 pupils used graphical calculators to explore functions of the form $y = mx$. They were shown how to let m take a range of values to produce a family of straight lines. They explored the effects of varying the sequence and range of values for m, including zero, large and/or negative values.

Year 8 pupils explored the effects of changing m and c in equations of the form $y = mx + c$, by fixing one of m, c and letting the other take a sequence of values. They observed the differences in the graphs produced; for example, a family of straight lines with gradient 3, and the family of straight lines passing through ($^-$2, 0). They understood and could explain why $y = 3x - 2$ was the only straight line fulfilling both criteria.

Able Year 9 pupils explored the effects of changing b and c when looking at the graphs of functions of the form $y = x^2 + bx + c$, as above, fixing one and letting the other vary across an incremented range of values. Pupils were able to predict effects of changing b and c, and were able quickly to find values of b and c to match a particular graph.

Year 8 pupils used a spreadsheet to explore what happens when different values are substituted in an expression (*Framework for teaching mathematics: Years 7, 8 and 9* (DfES 0020/2001), Section 4, page 139).

Year 9 pupils used a spreadsheet formula to increment values of x when using trial-and-improvement methods to solve the equation $y = x^3 - x - 10$ (*Framework for teaching mathematics: Years 7, 8 and 9* (DfES 0020/2001), Section 4, page 135).

Models and modelling

The ICT **models and modelling** strand relates closely to the mathematical structures and relationships explored in number, algebra, geometry and handling data. A range of applications can make significant contributions to teaching, pupils' learning and standards attained.

The ICT objectives for this strand use vocabulary that will be familiar to mathematics teachers, often to be found in *Using and applying mathematics*.

- Enter rules or formulae and check their appropriateness and accuracy and explain the rules governing a model. (Y7)
- Develop ICT-based models and test predictions by changing variables and rules. (Y8)
- Test hypotheses and predictions using models, comparing their behaviour with information from other sources. (Y9)

While other ICT applications may be appropriate here, the familiar mathematical tools of spreadsheets, graph-plotters, graphical calculators and dynamic geometry software can be used in this strand to engage pupils and to develop and enrich their mathematical knowledge, understanding and skills.

Year 7 pupils used spreadsheets to construct simple (one-step) formulae to model situations such as metric–imperial or currency conversion charts for use when going on a foreign holiday.

Using graphical calculators, Year 7 pupils explored the properties of graphs of straight lines through the origin. Pupils enjoyed making links from multiplication facts to points on a straight line, before exploring more general relationships, using decimal values on axes, and functions with decimal and negative gradients. The graphical calculators gave pupils the opportunity to link the function, graph and table, allowing many functions quickly to be compared.

Year 8 pupils used spreadsheets to construct simple formulae to model situations such as calculating sale prices following a given percentage discount, or calculating commission.

Year 8 pupils explored 'term-to-term' and 'position-to-term' features of simple sequences presented on a spreadsheet and, where possible, they devised algebraic expressions to describe the sequences. They made changes to the sequence before predicting, then investigating, the effects of those changes on the rules governing the sequences. The use of a spreadsheet provided them with rapid feedback, enabling them to focus on the link between changes to functions and number patterns produced. Following this lesson, they were able to predict linear functions for any step size from any starting number.

Year 9 pupils used a spreadsheet to construct formulae to model situations such as a mobile phone tariff based on a monthly rental charge plus the cost per minute of calls (*Framework for teaching mathematics: Years 7, 8 and 9* (DfES 0020/2001), Section 4, pages 142–3).

In exploring properties of linear functions of the form $ax + by + c = 0$, Year 9 pupils determined the equations of lines making up squares, rectangles, parallelograms and kites drawn on coordinate grids, by producing the images on graphical calculators. They then discussed the relationships between the geometrical properties of these shapes and the equations of the lines that enclosed their sides. By varying the sizes and proportions of the sides of the shapes, pupils made and tested conjectures relating to equations of parallel lines, perpendicular lines and lines reflected in $x = c$, where c is a constant.

(*Framework for teaching mathematics: Years 7, 8 and 9* (DfES 0020/2001), Section 4 page 13).

During the key stage, pupils will develop geometrical concepts and reasoning, using the conventions and definitions of geometrical models to derive new properties, using ICT where appropriate.

The *Guide to the Framework for teaching mathematics: Years 7, 8 and 9* (DfES 0020/2001), states:

ICT offers good opportunities to develop geometrical reasoning and an appreciation of shape and space. For example, pupils can use the programming language LOGO to explore properties of plane shapes, such as the exterior angles of polygons. With dynamic geometry software, they can use rapid geometric drawing to explore a condition such as 'one pair of opposite angles of a quadrilateral is equal', and discover the special circumstances under which the condition is true. More able pupils may be able to prove their conjectures analytically, but the formal use of congruent triangles is often needed, and for most pupils this will be tackled in Key Stage 4.

The teacher used an interactive whiteboard and dynamic geometry software when working on reflections with a Year 7 class. The dynamic nature of the software enabled pupils to see that mirror lines were always perpendicular bisectors of lines joining corresponding points in the object and the image. Working in pairs, on laptops, they explored the effects of moving points on the object, or rotating the mirror line. This meant that they did not develop the standard misconceptions associated with diagonal mirror lines, as the facility to drag elements on screen allowed any conflicts in understanding to be resolved immediately.

Using dynamic geometry software, Year 7 pupils were able to draw a generic triangle and reflect it in one of its sides. They used the dynamic nature of the software to move the vertices of the original shape and watch its image change. They then discussed the mathematical properties of the resulting quadrilateral.

Using dynamic geometry software to draw a generic triangle and rotate it about the mid-point of one of its sides, Year 8 pupils devised a construction leading to a conjecture that all triangles tessellate. They were able to move any vertex of the original triangle and watch the tessellation change, revealing an infinite number of possible tessellations. They then used their knowledge that the sum of the angles of a triangle is 180° to prove that their conjecture was correct. As an extension, some pupils used a similar procedure to explore whether quadrilaterals tessellate.

Dynamic geometry software was used to introduce a Year 8 class to ideas of proof. The teacher modelled a proof that vertically opposite angles are equal. Later in the lesson, pupils developed their understanding of corresponding and alternate angles to produce an informal proof that the sum of the angles of a triangle is 180°. Use of ICT helped them to establish what stays the same and what changes, as points and lines are moved.

Able Year 9 pupils introduced an incremental variable into their LOGO procedure for drawing a regular hexagon to explore 'snowflake' patterns. They were then able to adapt their program to produce other 'snowflakes' based on other regular polygons.

Modelling lies at the heart of probability, which focuses on links between experimental and theoretical outcomes. The role of ICT, as referred to in the *Guide to the Framework for teaching mathematics: Years 7, 8 and 9* (DfES 0020/2001), is:

Distinctive features of handling data:

■ Using ICT as a powerful source of data, and as a means of processing data and simulating situations.

During the key stage, pupils begin to understand that experimental outcomes from probability experiments, including ICT simulations, may differ significantly from theoretical models, but that as the number of trials becomes very large the proportion of successes converges to the theoretical probability. The use of these simulations can give pupils rapid access to large datasets of results of probability experiments for comparison with the theoretical models.

Year 9 pupils used the Smile™ program, *Loaded dice*, to roll weighted six-sided dice and graphical calculators to record, display and analyse data from the dice. The lesson exemplified how probability simulations can be used to generate experimental data for comparison with theoretical models. The use of graphical calculators or spreadsheets to draw on a range of statistical graphs allowed more time for data interpretation, which the teacher had targeted as an area that the class had found difficult.

Models are used extensively in Key Stage 3 mathematics to help pupils develop mathematical concepts and, increasingly, to help pupils explore their understanding by asking *What if …?* type questions. Commonly-used models include large, generic, source-free software packages, including spreadsheets, graph-plotters, graphical calculators and dynamic geometry software.

Through teacher questioning, Year 7 pupils established that the terms of the Fibonacci sequence that are even numbers are the 3rd, 6th, 9th, … . Pupils then used a spreadsheet to explore positions of multiples of 3, of 5, … in the Fibonacci sequence, leading to expressions of generality. They challenged each other to find the largest number of patterns linked to multiples. Most able pupils were set the task of explaining/proving why these patterns emerge.

Using a motion sensor, linked to an OHP graphical calculator, Year 8 pupils walked through some paths to produce straight-line graphs passing through the origin. Using seconds and metres from the sensor as scales, they discussed how to produce a graph approximating to $y = x$. They then explored how to produce $y = 2x$, $y = 0.5x$ … and graphs of the form $x + y = 6$. They rehearsed these movements before performing them later in the lesson.

Again, using the motion sensor, Year 9 pupils, 'walking the graph' discussed how to generate any straight-line graph and began to explore paths for simple quadratic graphs.

Examples of lessons supplied on the CD-ROM

The CD-ROM includes examples of mathematics 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 mathematics. They also broadly reflect the ICT key concepts identified on page 15 as being the most appropriate to apply and develop in the mathematics curriculum. The examples offer support for the teaching and learning of mathematics. 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 mathematics lesson.

Each example includes a description of the lesson to place it within the context of the curriculum. These identify the mathematics 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   **Transforming triangles**

Year group: 7

Mathematics objectives covered	Mathematics lesson summary

Pupils will be taught to:
 	
■ recognise reflective symmetry and recognise where a shape will be after a reflection;
 	
■ begin to identify and use angle, side and symmetry properties of triangles and quadrilaterals; solve geometrical problems involving these properties, using step-by-step deduction and explaining reasoning with diagrams and text;
 	
■ understand and use the language and notation associated with reflections, translations and rotations;
 	
■ recognise and visualise the transformation and symmetry of a 2-D shape:
 	
  – reflection in given mirror lines, and line symmetry;
 	
  – rotation about a given point, and rotation symmetry;
 	
  – translation;
 	
explore these transformations and symmetries, using ICT.
	This lesson uses dynamic geometry software to explore angles, side and symmetry in triangles and quadrilaterals made from triangles. In relation to the *Sample medium-term plans for mathematics* (DfES 0504/2001), the location of this lesson is in *Year 7, Shape, space and measures unit 2* (autumn term) or *unit 4* (summer term).
	
	Pupils will be expected to:
	
	■ explore movement in generic shapes, using dynamic geometry software to decide what changes and what stays the same;
	
	■ use the software to reflect a triangle in one of its sides to produce a quadrilateral;
	
	■ discuss which quadrilaterals can be created in this way.

The focus of this lesson on drawing and rapidly transforming geometric images gives this lesson a very close link to the ICT key concepts of **models and modelling**.

Lesson 2   Census at School

Year group: 8

Mathematics objectives covered	Mathematics lesson summary
Pupils will be taught to: ■ discuss a problem that can be addressed by statistical methods and identify related questions to explore; ■ construct, on paper and using ICT: – pie charts for categorical data; – bar charts and frequency diagrams for discrete and continuous data; – simple line graphs for time series; – simple scatter graphs; and identify which are most useful in the context of the problem; ■ interpret tables, graphs and diagrams, and draw inferences that relate to the problem being discussed; relate summarised data to the questions being explored.	In this lesson pupils begin by comparing their own class data on travel to school with data from the *Census at school* website. They continue by posing questions and answering them, using data directly from the website, or from the data file on the Strategy CD-ROM for *Interacting with mathematics in Year 8: Handling data*. The lesson is located in the *Sample medium-term plans for mathematics: Handling data unit 1* (autumn term) or *unit 2* (spring term) (DfES 0504/2001). **Pupils will be expected to:** ■ tabulate results and use frequency tables and bar charts to represent data; ■ make and test conjectures about data; ■ use pie charts to compare proportions in datasets; ■ recognise that variations in sample sizes determine the need for different divisors when calculating the mean; ■ understand that very small samples might affect the validity of any conclusions drawn.

The ICT use links to the key concept of **using data and information sources**. Pupils access data from the *Census at school* website, or from the Strategy CD-ROM to support handling data in Year 8. They make conjectures in the form of questions and use the data sets to answer these questions.

Lesson 3   Generating linear sequences

Year group: 8

Mathematics objectives covered	Mathematics lesson summary
Pupils will be taught to: ■ generate terms of a linear sequence, using term-to-term and position-to-term definitions of the sequence, on paper and using a spreadsheet or graphical calculator; ■ begin to use linear expressions to describe the *n*th term of an arithmetic sequence, justifying its form by referring to the activity or practical context from which it was generated.	This lesson is designed to support transitions in pupils' generalisations of sequences from term-to-term to position-to-term. The lesson, from *Sample medium-term plans for mathematics: Year 8, Number/algebra 1* (DfES 0504/2001), is positioned at the start of Year 8 so pupils will be building on algebraic skills learned during Year 7. **Pupils will be expected to:** ■ investigate a familiar sequence, generated by a spreadsheet formula; ■ use spreadsheets to reinforce their understanding of term-to-term and position-to-term descriptions of sequences; ■ begin to derive rules that can be expressed algebraically; ■ predict what will happen with changes to the starting number or the difference pattern of the sequence; ■ check their predictions quickly through the use of the spreadsheet; ■ explain the effects of changes to 'rules'.

The lesson could be adapted for use with graphical calculators, rather than spreadsheets. This would enable subsequent lessons to establish further links between functions and graphs.

The structure of the activity, and guidance supplied, supports the teacher's role in enabling pupil enquiry through effective questioning.

This ICT application of **models and modelling** provides rapid feedback from computers and graphical calculators, allowing pupils to explore the effects of changing equations and variables and to make links between different representations.

Lesson 4 **Generating polygons**

Year group: 9

Mathematics objectives covered	Mathematics lesson summary
Pupils will be taught to: ■ explain how to find, calculate and use: – the sums of interior and exterior angles of quadrilaterals, pentagons and hexagons; – the interior and exterior angles of regular polygons; ■ find simple loci, both by reasoning and by using ICT, to produce shapes and paths, e.g. *an equilateral triangle*; ■ solve substantial problems by breaking them down into simpler tasks, using a range of efficient techniques, methods and resources, including ICT; use trial and improvement where a more efficient method is not obvious.	These two lessons using LOGO fit well into the early part of *Shape, space and measures 1* in the *Sample medium-term plans for mathematics: Year 9* (DfES 0504/2001). **Pupils will be expected to:** ■ build upon their previous experience of LOGO, initially to write procedures to generate regular polygons; ■ establish and consolidate links between the number of sides of a regular polygon, the LOGO angle of turn and the size of the polygon's interior and exterior; ■ in the second lesson, amend earlier procedures to combine regular polygons to produce shapes that preserve their symmetries; ■ begin to understand recursion through snowflake patterns.

Pupils' ICT capacity will be developed in the areas of:

■ **automating processes**, through writing LOGO routines;

■ **models and modelling**, by developing ICT-based models and testing predictions;

■ **reviewing, modifying and evaluating work as it progresses**, in amending procedures for different purposes.

Lesson 5   **Population and development database**

Year group: 9

Mathematics objectives covered	Mathematics lesson summary
Pupils will be taught to: ■ interpret tables, graphs and diagrams for both discrete and continuous data, and draw inferences that relate to the problem being discussed; relate summarised data to the questions being explored; ■ interpret graphs and diagrams and draw inferences to support or cast doubt on initial conjectures; have a basic understanding of correlation; *analyse data to find patterns and exceptions, look for cause and effect and try to explain anomalies*; ■ compare two or more distributions and make inferences, using the shape of the distributions, the range of data and appropriate statistics; ■ gather data from specified secondary sources, including printed tables and lists from ICT-based sources; *identify which information may be required to pursue a further line of enquiry*.	These two lessons, which could be expanded to three, make use of a population and development database to encourage the analysis and interpretation of data collected from countries from around the world. They are aimed at able Year 9 pupils and, in relation to the *Sample medium-term plans for mathematics* (DfES 0504/2001), would be best placed in *Handling data unit 3*, in the summer term. The work here can contribute to preparing the ground for the demands of the handling data requirements of GCSE. **Pupils will be expected to:** ■ make and test hypotheses about population distribution and population growth in three countries; ■ access large datasets to explore whether correlation exists; ■ question whether it is reasonable to accept apparent correlation between datasets which appear to be unconnected; ■ discuss the extent to which correlation is causal when applied to complex real datasets where outcomes are subject to many and varied influences.

These lessons link to the ICT key concept of **organising and investigating**. Pupils make conjectures before using the *Population and development* database to explore, represent and interpret the data and draw conclusions.

Acknowledgements

Thanks are due to New Media for kind permission to reproduce lessons 1 and 5 from their Enhancing Subject Teaching Using ICT (CPD) materials. The lessons have 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 mathematics. 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**

Mathematics

Association of Teachers of Mathematics (ATM)	**www.atm.org.uk**
Mathematical Association	**www.m-a.org.uk**
Census at School	**www.censusatschool.ntu.ac.uk**
Population and development database	**www.alsagerschool.co.uk/subjects/ sub_content/geography/Gpop/HTMLENH/**

Cabri Géomètre	**www.cabri.com**
	www.chartwellyorke.com/cabri/html
Geometer's Sketchpad	**www.keypress.com**
	www.dynamicgeometry.co.uk
Smile	**www.smilemathematics.co.uk**
Count On	**www.counton.org**
Autograph	**www.autograph-math.com**

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 mathematics?
- 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 mathematics 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

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 in which it 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 that 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 mathematics National Curriculum

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 mathematics 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

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 mathematics.

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 mathematics.

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 mathematics.

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 mathematics.

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 mathematics?

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 mathematics* 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 mathematics 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 mathematics 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.

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	Developing ideas and making things happen	Exchanging and sharing information
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.	**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).	**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	Developing ideas and making things happen	Exchanging and sharing information
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.	**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).	**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.

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.

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