Using Information and Communications Technology to meet teaching objectives in secondary science

Introduction

The Initial Teacher Training (ITT) National Curriculum for the use of Information and Communications Technology (ICT) in subject teaching is applicable to training in all subjects in both the primary and secondary phases. For primary trainees, the curriculum applies to training in the core subjects (English, mathematics and science) and in their specialist subject(s). For secondary trainees, it applies to training in their specialist subject(s). As a result of the responses to the consultation on this curriculum, the TTA undertook to produce separate exemplification material to relate this curriculum to each subject in both phases. **This booklet relates the ITT National Curriculum for the use of ICT in subject teaching to the teaching of science in the secondary phase.**

Trainees and newly qualified teachers may also come across needs identification materials which the TTA has produced to support the New Opportunities Fund initiative. The format and content of the needs identification materials and this document are often similar. For example, the expected outcomes of the needs identification materials are based on the requirement in the ITT National Curriculum for the use of ICT in subject teaching, and much of the content of both documents was derived from the same source. There are, however, important differences between the documents, which reflect the different purposes for which they were written. The needs identification materials have been written to help serving teachers identify their needs in relation to the training available through the New Opportunities Fund. **This booklet has been written to help ITT providers, whether in schools or in higher education institutions, to teach secondary trainees how to use ICT in their science teaching.**

Everyone who now joins the teaching profession needs to be able to exploit the potential of ICT to meet their teaching objectives. ITT providers must therefore equip trainees to evaluate examples of ICT, both during their training and in their future employment; to make sound judgements about when, when not and how to use it, and to become confident and competent users of it. The development of the National Grid for Learning (NGfL) makes this even more important, since all teachers need to know how to maximise the NGfL's potential to secure higher standards of achievement from their pupils, to increase their own professional effectiveness, and to reduce their administrative burden.

We hope that ITT providers will use the exemplification material in this booklet as a resource to help them integrate the ITT National Curriculum for ICT into their secondary science training, in such a way that trainees learn to use ICT as a significant and integral part of their teaching rather than as an end in itself. Many of the examples illustrate ways to use technology that most trainees will find available in schools now; some illustrate ways to use technology that is not yet widespread.

The material is in FOUR sections:

Section One
(pages 3 to 4) explains how ICT can contribute directly to pupils' learning in secondary science, and how it can help trainees to organise that learning;

Section Two
(pages 5 to 27) sets out the ITT National Curriculum for the use of ICT in subject teaching, with a commentary to help trainers relate it to the teaching of secondary science;

Section Three
(pages 28 to 52) gives a case study example of how one secondary science teacher, having decided on specific teaching objectives, reviewed and selected suitable ICT to meet those objectives; it is designed to help trainers engage their trainees with the ITT National Curriculum for the use of ICT in subject teaching as it relates to secondary science;

Section Four

(pages 53 to 57) lists other sources of examples of the use of ICT in teaching secondary science, together with some addresses, to help trainers obtain further useful information and advice.

The booklet is offered as guidance only. It does not offer a course design; nor does it purport to be a comprehensive list of the ways in which ICT can support secondary science teaching; nor are ITT providers expected to include all the examples.

Section One

Using ICT in secondary science lessons

At the heart of the ITT National Curriculum for the use of ICT in subject teaching are **three key principles** which trainees need to know, understand and be able to apply.

1. Decisions about when, when not and how to use ICT in lessons should be based on whether **the use of ICT supports good practice in teaching the subject.** If it does not, it should not be used.

2. In planning and in teaching, decisions about when, when not and how to use ICT in a particular lesson or sequence of lessons **must be directly related to the teaching and learning objectives in hand**.

3. The use of ICT should either allow the trainee or the pupil to **achieve something that could not be achieved without it**; or allow the trainee to **teach or** the pupils to **learn something more effectively and efficiently** than they could otherwise; **or both**.

This will be important, whether:

- ICT is to be used by **all the pupils**: individually, in groups or as a whole class;
- ICT is to be used by **some pupils only**, e.g. for support or extension work;
- ICT is used by **the trainee**, e.g. in demonstrating to a whole class the function of the heart and circulatory system with presentation and multimedia hardware and software; in using a video microscope attached to a large screen to show Brownian motion or mitosis; in downloading lesson plans from the NGfL, or downloading selected resources from the Internet in advance of a lesson so that pupils can browse through them.

Trainees need to know that practical considerations may also play a part in their decisions about whether ICT should be used. These include the nature of the available resources: e.g. teaching objectives that could be met very effectively if a suite of computers were available in the classroom might not be attainable if there is just one stand-alone computer.

Secondary science trainees need to know that ICT has the potential to make a **significant contribution to their pupils' knowledge, understanding and skills in science**, through the use of:

i. **simulations and modelling,** to help pupils understand phenomena which may be too slow, too fast, too dangerous or too expensive to investigate in the school laboratory, and to allow them to investigate the effects of changing variables in the situations represented or to consolidate and reinforce conceptual understanding;

ii. **data logging**, e.g. using sensors to record variables such as temperature, moisture, light and pressure, to assist in the recording, presentation and analysis of results so that pupils can spend more time on interpretation, evaluation and the formulation of hypotheses about the implications;

iii. **databases and spreadsheets,** to enable pupils to organise, search and sort information in order to explore relationships, look for patterns and test hypotheses, e.g. extracting data on the nutrient value of different foods;

iv. **publishing and presentation software,** e.g. word processing and desktop publishing packages and multimedia authoring software, to enable pupils to develop understanding and present their findings to others;

vii. **information resources,** e.g. the Internet, CD-ROM and data files**,** to enable pupils to find information and thus to develop their knowledge and understanding of science.

These can all help pupils to

a. ask questions, predict and hypothesise;

b. observe, measure, record and manipulate variables;

c. interpret their results and evaluate scientific evidence;

d. present and communicate their findings in a variety of ways.

Trainees also need to know that ICT has the potential to offer **valuable support to the science teacher** by:

- **assisting in the preparation of teaching materials**;
- **helping to demonstrate experiments and concepts in science,** e.g. by using presentation packages for whole-class teaching;
- **supporting pupils working with primary sources of data** during investigative and practical work;
- **helping pupils to develop research and study skills in science**, e.g. when investigating secondary sources of data;
- **aiding record-keeping and reporting**, e.g. by storing and regularly updating formative records to monitor pupils' progress or to form the basis of a report.

Section Two

Commentary on the ITT National Curriculum

This section sets out the ITT National Curriculum for the use of ICT in subject teaching with a commentary relating it to the teaching of secondary science.

The ITT National Curriculum is presented on the left-hand pages, with some minor changes in wording helping to relate it directly to secondary science. The non-statutory examples in italics are retained where they are relevant to science, and in some cases supplementary examples have been added.

Opposite many sections of the ITT National Curriculum, there is a commentary offering examples of the way that the curriculum statements might be interpreted for secondary science training. No commentary has been offered where the curriculum statements apply equally to all subjects, or where it was thought that no further exemplification was needed.

The commentary sometimes refers to uses of ICT rarely found as yet in current science teaching. However, the use of ICT in subject teaching, like ICT itself, is dynamic and constantly changing. Although some elements of ICT are used by a minority of secondary science teachers at present, trainees will still need to be introduced to them and be aware of their educational potential.

The examples included do not purport to be an exhaustive list of the uses of ICT in science teaching.

INITIAL TEACHER TRAINING NATIONAL CURRICULUM FOR THE USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY IN SUBJECT TEACHING

SECONDARY SCIENCE

A. Effective teaching and assessment methods

1. **Trainees must be taught how to decide when the use of ICT is beneficial to achieve teaching objectives in secondary science, and when the use of ICT would be less effective or inappropriate.** In making these decisions, **trainees must be taught how to take account of the functions of ICT** and the ways that these can be used by teachers in achieving teaching and learning objectives in science. This includes:

a. how the speed and automatic functions of ICT can enable teachers to demonstrate, explore or explain aspects of their teaching, and pupils' learning, more effectively;

b. how the capacity and range of ICT can enable teachers and pupils to gain access to historical, recent or immediate information;

c. how the provisional nature of information stored, processed and presented using ICT allows work to be changed easily, *e.g. changing the distance/time values and observing the effect on a line graph*;

d. how the interactive way in which information is stored, processed and presented can enable teachers and pupils to:

i. explore prepared or constructed models and simulations, where relevant to secondary science;

ii. communicate with other people, locally and over distances, easily and effectively;

iii. search for and compare information from different sources;

iv. present information in ways that are accessible in different forms for different audiences.

Trainees should be taught what the implications of these functions are for achieving teaching objectives in science. *For example, the use of a calculator or a spreadsheet may remove the tedium of repetitive calculations and enable pupils to focus their attention on an emerging numerical pattern or the relationship between successive readings. However, trainees must be aware when pupils' skills in mental or written calculation are not being developed and therefore the activity may not suit the particular teaching objectives in hand.*

Commentary on 1

The implication of this section for science trainees is in understanding the functions of ICT that may contribute to effective science teaching, and how that understanding will inform their decisions on whether or not to use ICT in a particular teaching situation. There are functions of ICT which are specifically relevant to science teaching:

- *the immediate appearance on screen of automatically collected experimental results enables pupils to make the connection between observed and empirical data;*
- *access to current and relevant information sources (e.g. latest photographs from the Hubble space telescope) can be used to illustrate concepts which would otherwise be very theoretical;*
- *increasing precision in the use of scientific language and terminology can be encouraged when word processing software is used to produce reports and accounts of experiments;*
- *interaction with simulations and models allows pupils to test hypotheses and explore relationships between variables, e.g. to explore the effect of colour of light on oxygen production during photosynthesis.*

2. Trainees must be taught how to use ICT most effectively in relation to science-related objectives, including:

a. using ICT because it is the most effective way to achieve teaching and learning objectives, not simply to motivate pupils or as a reward or sanction for good or poor work or behaviour;

b. avoiding the use of ICT for simple or routine tasks which would be better accomplished by other means;

c. knowing that, where ICT is to be used, appropriate preparation of equipment, content and methodology is required;

d. avoiding giving the impression that the quality of presentation is of overriding importance and supersedes the importance of content;

e. structuring pupils' work to focus on relevant aspects and to maximise use of time and resource;

f. having high expectations of the outcomes of pupils' work with ICT, including:

i. expecting pupils to use ICT to answer valid questions appropriate to the subject matter being taught;

ii. when appropriate, requiring pupils to save work, and evaluate and improve it;

g. making explicit the links between:

i. the ICT application and the subject matter it is being used to teach;

ii. ICT and its impact on everyday applications.

Commentary on 2

The use of ICT in science lessons should always support pupils' efficient and effective learning, and trainees need to be able to explain why they have chosen to use ICT. For example, an animated simulation of the digestive system should be used because it is the most effective means of illustrating the functions of the organs, and not merely as a bonus for pupils when the teaching objectives have been met by other means. The selection of appropriate ICT should be judged carefully. For example, whereas for single temperature measurements it may be better to use a thermometer, varying temperature changes can be recorded and displayed more effectively with a data logger and temperature sensor. Data loggers may also be particularly useful when two or more measurements are made simultaneously.

Trainees must know how to structure pupils' work with ICT to maximise their learning and make best use of available time. They should be familiar with the operation of the equipment and organise the lesson so that the focus is firmly on the teaching objectives in science. For example, when pupils are researching information from the Internet, an intranet or a CD-ROM, trainees should encourage them to select, evaluate and interpret information, rather than copying sections, e.g. by posing a series of questions for pupils to answer; by book-marking a limited number of sites, or by limiting the length of a report so that pupils have to précis. When pupils are analysing data, trainees should teach them to use appropriate data analysis tools, such as lines of best fit on graphs.

Today's scientists make extensive use of ICT, and trainees should understand the contribution that ICT makes to modern science, so that they can discuss examples with their pupils, such as the way in which spreadsheets are used to analyse and model numerical data.

3. For those aspects of lessons where ICT is to be used, **trainees must be taught to identify in their planning:**

a. the way(s) in which ICT will be used to meet teaching and learning objectives in science;

b. key questions to ask and opportunities for teacher intervention in order to stimulate and direct pupils' learning;

c. the way(s) in which pupils' progress will be assessed and recorded;

d. criteria to ensure that judgements about pupils' attainment and progress in science are not masked because ICT has been used;

e. any impact of the use of ICT on the organisation and conduct of the science lesson and how this is to be managed;

f. how the ICT used is appropriate to the particular science-related objectives in hand and to pupils' capabilities, taking account of the fact that some pupils may already be very competent, *e.g. because of home access or through participation in extra-curricular ICT activities,* and some may need additional support.

4. **Trainees must be taught the most effective organisation of classroom ICT resources to meet learning objectives in science**, including how to:

a. use ICT with the whole class or a group for introducing or reviewing a topic and ensuring that all pupils cover the key conceptual features of the topic, *e.g. through the use of a single large screen or display*;

b. organise individuals, pairs or groups of children working with ICT to ensure that each participant is engaged, that collaborative effort is balanced, and that teacher intervention and reporting back by pupils takes place where appropriate;

c. make ICT resources available to pupils for research or other purposes which may arise either spontaneously during lessons or as part of planned activity, ensuring that the resource is used profitably to achieve science-related objectives;

d. position resources for ease of use, to minimise distraction, and with due regard to health and safety;

e. ensure that work done using ICT is linked to work away from the screen, allowing ICT to support teaching rather than dominate activities, *e.g. providing sufficient desk/floor space around the hardware to enable the ICT to be used with other materials; providing space to write as well as input from the keyboard; positioning ICT so that pupils are able to sit facing the teacher when required.*

Commentary on 3

Trainees should be taught to plan the use of ICT into their lessons in a systematic way. They will need to:

- *consider the way in which ICT is to be used in the lesson: for example, how the use of a set-up file giving the initial experimental conditions for measuring the rate of a chemical reaction may lead to better understanding of factors affecting the rate of reaction;*
- *anticipate the need for, and prepare, key questions to ask in lessons, such as "What will happen to the volume if you change the value of pressure in the spreadsheet?";*
- *be clear about how achievement in science will be assessed and understand the role of ICT in that achievement, e.g. in considering whether the content of a written report is accurate in terms of science and not just whether the report is attractively presented;*
- *differentiate for pupils' ability and previous experience: for example, careful organisation of groups may enable pupils with home access to the Internet to support other pupils with on-line research.*

Commentary on 4

There are various ways of organising the use of ICT in the science classroom, and trainees should be aware of strategies and able to apply them appropriately. For example:

- *when demonstrating acid-base titrations, using a large screen display (e.g. a digital projector and large screen, or a television) to enable the pupils to observe the physical changes, watch the data being collected, and allow the trainee to comment on the reaction taking place;*
- *during an investigation into 'huddling of animals', employing strategies such as 'jigsaw' to ensure that all pupils contribute to the work, e.g. assigning one pupil to be responsible for retrieving relevant information from a CD-ROM on behalf of the group;*
- *providing a CD-ROM database of elements in the periodic table so that pupils can research materials suitable for a specific purpose, such as packaging;*
- *ensuring that computers are safely positioned, e.g. when using data loggers to collect data for cooling curves;*
- *integrating the entering of data on a computer spreadsheet with the taking of measurements from an experiment by manual methods;*
- *providing access to an Internet or intranet link to allow pupils to search for additional information about the solar system.*

5. **Trainees must be taught to recognise the specific contribution that ICT can make to teaching pupils with special educational needs** in mainstream classrooms based upon the need to:

a. provide access to the curriculum in a manner appropriate to pupils' needs;

b. provide support specific to science.

6. **Trainees must be taught how to choose and use the most suitable ICT to meet teaching objectives**, **by reviewing a range of generic and science-specific software critically**, including how to:

a. assess its potential for helping to meet teaching objectives;

b. judge its suitability for the age of pupils, their stage of development, and their prior experiences, taking account of language, social and cultural background;

c. evaluate the success of its use in relation to teaching objectives.

7. **Trainees must be taught how to contribute to the development and consolidation of pupils' IT capability** within the context of science through:

a. explicit discussion and, where necessary, teaching of the IT skills and ICT applications which are used in science;

b. using ICT terminology accurately and appropriately, and explaining to pupils any ICT terminology which arises from the application of ICT to science;

c. using ICT in ways that provide models of good practice for pupils, and insisting that pupils employ correct procedures when using applications.

Commentary on 5

Trainees should be taught the ways in which ICT can support learning in science. For example, reluctant writers can be encouraged to complete written reports of their practical work with a word processing package, using templates and word banks. Conceptual understanding can be reinforced by exercises that require pre-prepared sentences to be put in the correct order. Where pupils have a physical disability, sensors can give them the opportunity to collect their own experimental data: for example, visually or physically impaired pupils might experience difficulty in reading or manipulating thermometers, but could access and record temperature measurements with a sensor and data logger.

Commentary on 6

Trainees should be taught how to evaluate science software for teaching purposes and develop criteria to assess the suitability of such software to meet teaching objectives: for example, a multimedia program about the body may have appealing graphics, but its content may be pitched at too high a level. Trainees should be aware of sources of reviews such as the Secondary Science Review, Web sites and journals.

Commentary on 7

Trainees can exploit the numerous opportunities to develop pupils' IT capability when using ICT to achieve objectives in the science curriculum. For example, pupils using a spreadsheet to model energy losses in a house can assess the plausibility and realism of the model; this will give them opportunities to test the effects of energy-saving measures (pupils' NC for science) and to develop critical understanding of the use of a spreadsheet (pupils' NC for IT). In discussing such a model with pupils, trainees should use terms such as 'cell', 'row', 'column', 'formula' where appropriate, to encourage pupils to use these terms themselves. They should model, and insist on, good practice in the use of ICT: for example, pupils can be shown how to save their own spreadsheet in a consistent way with a sensible name in a suitable folder.

8. In order to understand how to monitor, evaluate and assess their teaching and pupils' learning in science when using ICT, and to evaluate the contribution that ICT has made to the teaching of science, trainees must be taught:

a. how to **monitor pupils' progress** by:

i. being clear about teaching objectives and the use of ICT in achieving them;

ii. observing and intervening in pupils' ICT-based activities to monitor and support their progression towards the identified objectives;

iii. asking key questions which require pupils to reflect on the appropriateness of their use of ICT;

b. how to **recognise standards of attainment in science** when ICT resources are used, including:

i. recognising how access to computer functions might change teacher expectation of pupil achievements;

ii. identifying criteria by which pupils can show what they have learnt as a result of using ICT-based resources from the Internet or CD-ROM, and insisting that pupils acknowledge the reference sources used in their work;

iii. how to determine the achievement of individuals when the "product" is the result of a collaborative effort, through observation, record keeping, teacher intervention and pupil-teacher dialogue;

iv. how to ensure that assessment of ICT-based work reflects pupils' learning and the quality of their work within science rather than just the quality of presentation or the complexity of the technology used;

c. how to **use formative, diagnostic and summative methods of assessing pupils' progress in science where ICT has been used,** including how to set up ICT activities with targeted objectives for assessment and make provision in those activities for all pupils to demonstrate achievement, conceptual understanding and learning through the use of ICT.

9. [This section of the curriculum has been omitted since it refers only to trainees on courses providing for pupils aged 3-8 and 3-11.]

10. Opportunities to practise

Trainees must be given opportunities to practise, in taught sessions and in the classroom, those methods and skills described above.

Commentary on 8

Trainees must be taught to evaluate achievement in science when ICT is used in science lessons. This will involve the trainee in:

- *setting clear objectives and understanding the role of ICT in achieving them. For example, if a graphing package has been used to explore the relationship between current and voltage, the assessment of pupils' achievement should be based on their understanding of this relationship and not on their ability to use the graphing package;*
- *making pupils reflect on the role ICT has played in their work e.g. asking them to consider the advantages of using a temperature probe for recording daily temperature variations over using an ordinary thermometer;*
- *using both ICT and non-ICT approaches to a task with a class and evaluating the contribution ICT has made to the task: for example, investigating rate of chemical reaction may be done with 'disappearing cross' experiments by some groups and with light sensors by other groups;*
- *requiring pupils to interpret and present the information gained from the use of ICT resources for a specific purpose rather than simply printing off information, e.g. inviting pupils to produce a summary in a limited number of words on global warming from a CD-ROM or from Internet sites;*
- *using a variety of strategies and interventions during the lesson to assess pupils' progress and contributions, e.g. encouraging pupils to keep a record of their own actions and findings, or to write asking for printouts of early drafts of reports.*

B. Trainees' knowledge and understanding of, and competence with, information and communications technology

11. In relation to the ICT content set out in paragraphs 12 to 19, trainees must be given opportunities to:

a. evaluate a range of information and communication technologies, and the content associated with them, *e.g. television and radio, video, computers, the Internet, intranets, data logging devices, cameras and other equipment,* justifying the selection and use of ICT in relation to aspects of their planning, teaching, assessment and class management, including for personal professional use, *e.g. in downloading on-line materials for teaching or writing reports*;

b. understand and use correctly the specialist terms associated with the ICT used in science which are necessary to enable them to be precise in their explanations to pupils, to discuss ICT in relation to science at a professional level, and to read inspection and classroom-focused research evidence with understanding.

12. Trainees must demonstrate that they are competent in those areas of ICT which support pedagogy in every subject, including that they:

a. can employ common ICT tools for their own and pupils' benefit, *e.g. word processing, e-mail, presentation software, data handling,* **and can use a range of ICT resources, at the level of general users** (rather than as network or system managers), including:

i. the common user interfaces, using menus, selecting and swapping between applications, cutting, pasting and copying files, and cutting, copying and pasting data within and between applications;

ii. successfully connecting and setting up ICT equipment, including input devices, *e.g. a mouse, touch screen, overlay keyboard, microphone* and output devices *e.g. printers, screens and loudspeakers*;

iii. loading and running software;

iv. file management;

v. seeking and using operating information, including from on-line help facilities and user guides;

vi. coping with everyday problems and undertaking simple, routine maintenance, with due consideration to health and safety;

vii. understanding the importance of passwords and the general security of equipment and access to it;

b. know and understand the characteristics of information, including:

i. that information must be evaluated in terms of its accuracy, validity, reliability, plausibility, bias;

ii. that information takes up memory and that there are implications when saving and compressing files;

iii. that information has to be stored somewhere;

iv. that ICT systems can present static information or changing information;

v. that information can be directly and dynamically linked between applications;

vi. that applications and information can be shared with other people at remote locations.

Commentary on 12.a

The purpose of using ICT in science is to raise the standards of pupils' achievement and the quality of their learning. In order to realise the potential of ICT to extend and enhance learning, science trainees will need to be competent users of computer systems typically found in schools. This will include both generic operations such as using a word processing package for the production of a worksheet and more specific science activities such as setting up a data logging system. Trainees will need to develop effective management skills, such as organising and storing files, allocating class resources, categorising Internet book-marks and finding and solving minor technical difficulties. Trainees should also be competent users of audio and video equipment.

Commentary on 12.b

The growth of scientific information available through ICT makes it all the more important for trainees to understand the nature and characteristics of information and data. They should be aware of the authenticity, accuracy, and potential bias of material. For example, when researching information about enzymes from the Internet, trainees should be aware that the available information may come from sources ranging from commercial producers of enzymes, with a vested interest in selling enzymes, to academic organisations with factual and research information about enzyme reactions.

The availability of ICT animations, video, and sound can extend the strategies of teachers when illustrating and explaining science concepts. Trainees should know, however, that such resources may require significant memory for storage (and may take considerable time if they need to be downloaded from the Internet), and that this should be considered when planning to use such resources. They should understand how to estimate or find the memory requirements of such resources.

Trainees should be familiar with the opportunities presented when information and data is compatible between ICT applications and packages. This is particularly useful when collating data from pupil investigations, e.g. on variation in human characteristics, when charts and graphs can be dynamically built up as data is added to a table. Trainees should realise the potential of remote access to data and applications, such as the value to pupils of requesting and downloading current astronomical images from remotely operated telescopes.

13. Trainees must demonstrate in relation to secondary science that they:

a. know how to use ICT to find things out, *including, as appropriate for secondary science:*

i. identifying sources of information and discriminating between them;

ii. planning and putting together a search strategy, including framing useful questions, widening and narrowing down searches;

iii. how to search for information, including using key words and strings and logical operators such as AND, OR and NOT, indexes and directories;

iv. collecting and structuring data and storing it for later retrieval, interpretation and correction;

v. interpreting what is retrieved;

vi. considering validity, reliability and reasonableness of outcomes;

b. know how to use ICT to try things out, make things happen and understand how they happen *as appropriate for secondary science:*

i. exploring alternatives;

ii. modelling relationships;

iii. considering cause and effect;

iv. predicting patterns and rules recognising patterns, and hypothesising;

v. knowing how to give instructions;

vi. sequencing actions;

vii. defining conditions, e.g. "if this happens, do that…";

viii. understanding how feedback works and the difference between things that do and do not rely on feedback;

c. know how to use ICT to communicate and exchange ideas *as appropriate to secondary science:*

i. presenting ideas, including: identification of audience and purpose; deciding the best means with which to communicate;

ii. exchanging ideas, including identifying the most appropriate medium, and information.

Commentary on 13.a

Accessing and interpreting data and information from ICT resources require trainees to have certain skills. They will need to know the source of the information and be able to identify any bias and its likely effect on the outcome. For example, they should be able to discriminate between pollution data provided by environmental pressure groups and by industrial sources.

Trainees will need to be able to find effective ways of retrieving information from large data sets. This will require them to develop search skills using more than one criterion for the search, e.g. finding metallic elements with melting points less than 1000°C from a database of elements and compounds. They will need to be able to select information from original sources to be used in different situations. This may require selection and reorganisation of data for teaching purposes, e.g. in producing a restricted data set of information about plastics from a commercial source.

Commentary on 13.b

Secondary science trainees will all be familiar with the processes of exploring the effects of changing variables, investigating relationships between variables, and considering cause and effect. These are all crucial processes of learning science, and the science trainee will need to develop skills in using ICT to support them. For example, the use of software such as a spreadsheet to analyse graphically data collected from an investigation about the factors affecting stopping distance can enable the relationship between the variables to be explored more effectively.

Trainees should understand how to use data logging software to investigate trends in data, e.g. how to give simple instructions to the system and understand the range of commands and parameters required for particular experiments: for example, starting the monitoring of environmental data at a given time, or triggering on the zero point of a pendulum swing to enable comparisons to be made for oscillations of different amplitudes.

Commentary on 13.c

Communication of ideas and concepts is an important area of science teaching, and can be enhanced by the use of ICT. Trainees should understand the ways in which ICT can be used for whole-class and individual work. They should, for example, be able to use presentation and multimedia software to present material to pupils in attractive and accessible ways, integrating text, pictures and sound when appropriate. They should realise the functions of ICT that enhance communication and how ICT can support their teaching.

For example, by collecting resources from a range of sources (e.g. the Internet or CD-ROM), a trainee

could create a simple illustration of the function of the lungs to teach about human respiration. When communicating ideas, trainees will need to be able to select resources and software packages that meet their teaching objectives.

14. **Trainees must demonstrate that they know** those features of ICT which can be used, separately or together, to support teaching and learning in science, including:

a. **speed and automatic functions** – the function of ICT which enables routine tasks to be completed and repeated quickly, allowing the user to concentrate on thinking and on tasks such as analysing and looking for patterns within data, asking questions and looking for answers, and explaining and presenting results, *as appropriate to secondary science*, including how ICT can be used to:

i. measure events at long or short time intervals in order to compress or expand events which would normally take very short or long periods of time, and illustrate them to pupils at speeds appropriate to their pace of learning;

ii. measure and record events which might otherwise be impossible to gather within a classroom environment;

iii. explore sequences of actions and link the sensing of events with the control of actions;

b. **capacity and range** – the function of ICT, *as appropriate to secondary science,* to access and to handle large amounts of information; change time scales, or remove barriers of distance; give teachers and pupils access to and control over situations which would normally be outside their everyday experience, including:

i. the range of forms in which ICT can present information;

ii. the range of possible appropriate ICT sources, including local sources such as CD-ROM, and remote databases such as the Internet and the National Grid for Learning;

iii. how to judge the accuracy of the information and the credibility of its source;

iv. how ICT can be used to gain access to expertise outside the classroom, the school and the local community through communications with experts;

c. **provisionality** – the function of ICT which allows changes to be made easily and enables alternatives to be explored readily, and *as appropriate to secondary science:*

i. how to make best use of the ability to make rapid changes, including how to create text, designs and models which may be explored and improved in the light of evaluation;

ii. how to judge when and when not to encourage exploration and change using ICT;

iii. how saving work at different stages enables a record to be kept of the development of ideas;

d. **interactivity** – the function of ICT which enables rapid and dynamic feedback and response, *as appropriate to secondary science*, including how to determine the most appropriate media to use.

Commentary on 14.a

Trainees should understand the characteristics of ICT that can be of benefit to science teaching. By sampling regularly and at short time intervals, data loggers can capture experimental data that would otherwise have been difficult to obtain, and over extended time intervals they can reveal important trends in the data that illustrate scientific principles. This feature of ICT is exploited, for example, when demonstrating the variation of plant growth according to light level using data sampled regularly over a number of days.

Commentary on 14.b

Scientific information is available from a number of ICT sources. Science trainees should be aware of these sources and be able to assess the validity of the information. They should know how to access information, e.g. from CD-ROM or the Internet, and be aware of the particular opportunity presented by the use of remote sources of information from science experts. This can be beneficial to pupils when researching topics for investigation.

Commentary on 14.c

Scientific exploration is frequently based on an iterative approach to finding information and solving problems. Science trainees should understand how the functions of ICT support this type of approach. For example, hypotheses can be quickly and easily tested, allowing pupils to explore their own ideas. However, the trainee should understand when this approach is not appropriate for particular reasons, e.g. demands on time, or possible reinforcement of misconceptions, or departure from identified teaching objectives.

Commentary on 14.d

Science trainees should know how the interactive nature of ICT can develop pupils' knowledge and understanding. This is a fundamental function of ICT, and a key to effective learning. For example,

pupils can gain feedback on their decision-making when they engage in multimedia simulations, or make connections between physical observations and the on-screen graphical data that appear immediately during data logging experiments.

15. Trainees must demonstrate that they are aware of the potential of ICT to enable them to prepare and present their teaching more effectively, taking account of:

a. the intended audience, including matching and adapting work to subject matter and objectives, pupils' prior attainment, reading ability or special educational needs; recognising the efficiency with which such adaptations can be made using ICT;

b. the most appropriate forms of presentation to meet teaching objectives, *e.g. illustrating or explaining using: text; sound; still or moving pictures; live video links; illustrations, graphics or animations; numbers, graphs or charts, separately or in combination*.

16. Trainees must demonstrate that they:

a. know and understand the ICT requirements of the pupils' National Curriculum in relation to secondary science;

b. are familiar with the standards as set out in the pupils' National Curriculum for IT, relevant to the secondary phase, and know the level of IT capability they should expect of pupils when applying ICT in science.

17. Trainees must demonstrate that they know how each of the following is relevant to secondary science:

a. Generic procedures and tools, including:

i. understanding the key features and functions used within science;

ii. using ICT to prepare material for pupil use;

b. reference resources, including:

i. how to search reference resources;

ii. how to incorporate the use of reference resources into teaching;

c. the ICT specific to science:

i. the major teaching programs or "courseware" and how to ensure that material is matched to

the pupils' competences;

ii. where content and activities are presented in sequence to teach specific topics;

iii. where teaching activities are combined with assessment tasks and tests.

Commentary on 15

Science trainees should be able to use ICT to develop and adapt teaching materials, taking account of the needs of the teaching groups involved. This could mean, for example, developing spreadsheet templates with differing levels of interaction for pupils depending on their ability. Trainees should also be aware of the most effective ways of presenting ideas to pupils: for example, the visual impact of animation or video on pupils' conceptual understanding of science topics.

Commentary on 16

Science trainees should be aware of the explicit references to ICT in the programmes of study in the pupils' NC for science.

They should also understand the contribution that science can make in developing pupils' IT capability, particularly in the areas of measuring and modelling, and consider how this can be achieved within science lessons.

Commentary on 17.a

Science trainees should be familiar with the use of word processing software and spreadsheets, and understand how they can be used in science teaching, e.g. in writing reports, organising data, graphing and modelling.

Science trainees should also know how to use these tools to prepare material for pupils to use, e.g. instruction sheets and worksheets using word processing software, or data collection templates using a spreadsheet.

Commentary on 17.b

Science trainees should know how to use common information resources, access information and incorporate that information into teaching materials. For example, they should be able to use a search engine to find information about experimental DNA isolation, download the information, and (using cut and paste techniques) develop a set of instructions for pupils from this material. Trainees should be aware of copyright issues when using source material in the classroom.

18. Trainees must demonstrate that they are aware of:

a. the current health and safety legislation relating to the use of computers, and can identify potential hazards and minimise risks;

b. legal considerations including those related to:

i. keeping personal information on computers, as set out in the Data Protection Act;

ii. copyright legislation relating to text, images and sounds and that relating to copying software;

iii. material which is illegal in this country;

c. ethical issues including:

i. access to illegal and/or unsuitable material through the Internet;

ii. acknowledging sources;

iii. data confidentiality*, e.g. sensitive personal information such as weight or biological relationships*;

iv. the ways in which users of information sources can be (and are) monitored;

v. material that may be socially or morally unacceptable.

19. Trainees must demonstrate that they know how to use ICT to improve their own professional efficiency and to reduce administrative and bureaucratic burdens, including:

a. using ICT to aid administration, record-keeping, reporting and transfer of information;

b. knowing about current classroom-focused research and inspection evidence about the application of ICT to teaching science, and where it can be found;

c. knowing how to use ICT to join in professional discussions and to locate and access teaching plans, material and other sources of help and support, including through the National Grid for Learning;

d. knowing how ICT can support them in their continuing professional development.

Commentary on 19

Science trainees should know how ICT can support their own professional development. They should be aware of key sources of research and inspection evidence about ICT in science. They should understand how to set up and keep records of pupils' attainment using ICT. They should be able to find sources of information and case studies of how ICT can be used in science, e.g. from the NGfL, and to draw upon the knowledge and support of other science teachers through subject association discussion forums, e.g. to e-mail a group of chemistry teachers to seek answers to a query about the unexpected results of a chemistry experiment.

Section Three

Three case studies

This section provides a case study example from each of the three sciences, chosen to help trainers raise and discuss with their trainees issues such as:

- how to start with teaching and learning objectives in secondary science;
- how to consider the potential contribution of ICT to achieving these objectives;
- how to determine why ICT should, or should not, be used;
- where ICT *is* used, how to justify its use in terms of improvements in teaching and learning.

In using these case studies, trainers could, for example:

- select an aspect of the way in which ICT is used in the lessons, and explore alternatives;
- delete the sections explaining the teacher's decisions about ICT, ask trainees to suggest what the thinking might have been, and then discuss the text of those sections;
- consider with trainees how the teaching approach might have differed if different ICT resources had been available.

The case studies also illustrate how the use of ICT can support and enhance high quality science teaching, but cannot replace it. The organisation of resources and the identification of assessment methods are both considered in the teachers' planning of the units of work.

The case studies also provide a context for discussing aspects of the ITT National Curriculum for the use of ICT in subject teaching such as:

- the importance of teacher preparation when ICT is used in science lessons;
- the effective use of ICT-based data handling and modelling activities to investigate multi-variable systems;
- the use of multimedia software to simulate environments;
- the role of the teacher when ICT is used in science lessons;
- the advantages of using data logging equipment to investigate the rates of chemical reactions;
- the effective use of CD-ROM and Internet images and animated sequences to enhance science teaching;
- the importance of evaluating ICT-based resources that are to be used in science lessons;
- how spreadsheets can help pupils to interpret scientific data.

The case studies also illustrate how several aspects of the ITT National Curriculum for the use of ICT in subject teaching might be taught in an integrated way in secondary science training, with ICT issues routinely introduced into discussions about science between trainee(s) and tutor(s). For example, although these case studies show the effective use of ICT in relation to just a few teaching objectives in secondary science, trainees and their tutors, in discussing them, could consider many of the areas required by the statutory curriculum for the use of ICT.

Case Study 1 – Life processes and living things

Investigating simple predator-prey relationships

This is an example where the teacher made considerable use of ICT to help Year 10 pupils to understand the ways in which competition and predation affect the numbers of organisms in a habitat, and to consider how knowledge of these factors can enable habitats to be managed. The whole unit of work described took place in the computer room.

Teaching Objectives for the unit of work

For pupils to:

i. know that competition and predation affect the numbers of organisms in a habitat;

ii. explore the patterns and relationships between variables;

iii. be aware of the factors to be considered when managing habitats.

Pupils' National Curriculum references

This case study focuses on the following areas of the pupils' National Curriculum for secondary science: Key Stage 4.

Life and Living Processes

Living things in their environment – adaptation and competition

i. how the distribution and relative abundance of organisms in a habitat can be explained in terms of adaptation, competition and predation;

ii. how the impact of human activity on the environment is related to population size, economic factors and industrial requirement;

Background information and notes

i. This unit of work was carried out with a Year 10 GCSE mixed-ability science group.

ii. The unit of work looked at how organisms adapt to their surroundings and explored relationships between the numbers of organisms in a particular habitat. The impact of human activity on the environment was an issue of real concern for these pupils, and the teacher wanted his strategies for teaching to build on their interest. He would have liked to take pupils on a field trip to a specialist environmental centre or nature area where pupils could have gained first-hand experience of the issues they were to study. However, because of resource constraints, this was not possible. He decided to use the ICT-based modelling activity as an alternative way of meeting the specified teaching objectives.

iii. The teacher judged that data handling and modelling activities had great potential for helping him to meet the specified teaching objectives. In previous years his approach to this topic would have involved pupils in investigating relationships using secondary source material, such as tables of data or text-based material. However, he had noticed that, when using this approach, pupils' analysis was often limited by their mathematical ability to manipulate, present and interpret the data, and analysis was likely at best to be restricted to the consideration of two variables. The use of modelling software, however, allowed pupils to investigate multi-variable systems, and to see the resultant effects in a graphical format. The software in use gave scope for pupils to set parameters, change data and introduce random effects. Iterations of the model could be run for a pre-determined number of occurrences. Output from the software was in the form of a graph of species number against time.

iv. The activity described was based in a computer room; it could have been organised with a single machine in a science laboratory, but this would have increased the burden on the teacher in terms of monitoring and organisation. The software was accessed over a local area network, but could equally well have been accessed from the hard disk of each computer used.

v. The pupils in this group were familiar with using standard applications such as word processing and spreadsheets, and were competent in generic operations such as saving, loading and printing. They had had some experience in using software more specifically related to science, such as data logging and simulation, through planned curriculum activities in KS3 science lessons.

vi. The teacher was familiar with a modelling environment, and had used both specific modelling packages and generic spreadsheets with pupils for this purpose.

vii. Pupils worked in small groups. During the activity, to put their science work into context, the class was given a "scenario" to investigate. This "scenario" described the management responsibilities of a ranger in a country park close to a large metropolitan conurbation; such a scenario could readily be adapted to suit pupils in a different school. The ranger had to consider the use of land for recreation, conservation and the small-scale production of consumer crops.

Sequence of work in order to meet stated teaching objectives

N.B. The unit of work is set out in logical steps. These do not necessarily correspond to lessons.

Step 1 – teacher preparation

As part of the preparation for the lesson, the teacher familiarised himself with the use of the software chosen. He used some non-contact time in school to do this, but then decided to borrow one of the school's portable computers to continue the work at home. He prepared "help sheets" to assist pupils with the operation of the software, and found that this was also a very effective way for him to learn and understand the operation of the software. The teacher used a word processing package to prepare the help sheets and other resources such as worksheets. This allowed him to tailor the resources to the needs and abilities of the particular group.

Step 2 – introducing the topic

As a stimulus and an introduction to the unit of work, the teacher used multi-media CD-ROMs that enabled pupils to tour a countryside park looking at and clicking on the animals and plants they might find there. The class gathered around a large screen display and the teacher chose a pupil to browse around the 'virtual' park using the mouse, while he took the pupil's place in the class, from where he could watch alongside the class and intervene to offer commentary or pose questions.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The topic was introduced using a multimedia software package and a large screen display. Video or recall from a visit would have provided an alternative source of stimulus. The teacher asked the pupil to demonstrate so that he was free to watch the screen and interact with the class.

Commentary on specific teaching points

The pupil demonstrator responded to other pupils' suggestions, e.g. *"Go right!"* or *"Click on that"*. At certain points, the teacher interjected comments such as "*Let's just have a look at that area again - what did you see?"*: *"Why do you think those were found there?"*.

Step 3 – establishing pupils' prior knowledge

The teacher asked the pupils to consider the range of organisms that might be found in the park. The teacher led a whole-class discussion focusing on a limited number of the organisms found and asked pupils to predict the interdependence of the organisms on each other.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

This was done as a class brainstorm, with the teacher using the board. It could have been done using ICT, e.g. using an OHP, a word processor or an interactive white board. However, the teacher felt that ICT offered no advantage or enhancement to the science task.

Commentary on specific teaching points

The teacher's role here was to guide and direct the collective list. Questions were posed such as *"Which animal will you find the most of?"*: *"Why do you think they are found there?"*.

The teacher then led the class on to the next stage of the task by asking them how they could investigate relationships between the number of species.

Step 4 – introducing the software

The modelling software was introduced to the class with a short demonstration from the teacher using the large screen display. He explained that output from the model was in the form of graphs of number of species against time.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The teacher considered the large screen display to be the most effective way of showing all the class the instructions and operations needed to use the software.

Commentary on specific teaching points

This was an instructional mode of teaching, which allowed the teacher to cover important points, such as: *"Click here to reset all your numbers of animals"*, to the whole class in a consistent manner. The teacher judged that it would have been very difficult to communicate this knowledge quickly and effectively to a large group in any other way.

Step 5 – pupils' task (i): initial exploration

The class was divided into seven groups of four, and each group was allocated a computer. They spent a short time in their groups exploring the software and its operation. The teacher had prepared simple tasks to structure their exploration, e.g. *"Find the effects of clicking on the following buttons: …"*.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

This was valuable time for both pupils and teacher and had been planned into the lesson. The exploration allowed the pupils to find out what they and the software could achieve, and the teacher to help with any problems that arose.

Commentary on specific teaching points

Because the teacher had spent time becoming familiar with the software, he was able to troubleshoot, quickly sorting out any difficulties experienced by groups in loading or operating the software.

Step 6 – pupils' task (ii): finding out

The class was then asked to focus on relationships between animals typically found in the parkland over varying periods of time. They were given a worksheet describing the scenario to be investigated. The sheet told them that they had to manage the parkland in order to achieve as wide a diversity of species as possible, by providing appropriate food and conditions. Pupils were given initial starting conditions and asked to explore the population numbers of species using the modelling software. The pupils were guided through this activity by a set of structured and graded tasks provided by the teacher. The tasks became increasingly open-ended, involving more variables, as the pupils progressed towards setting their own initial parameters to attain a given population number for each species, and to establish a balance between them.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The use of this software allowed pupils to investigate predator/prey relationships in a dynamic way. They could ask 'what would happen if...' questions and see the effects of their hypotheses. This approach enhanced the pupils' science skills both in terms of process and knowledge of content. The teacher considered this to be the most effective way of involving the pupils in this activity.
The choice of software that could be used intuitively by the pupils reduced the number of technical and operational problems that arose in the lesson. The teacher was able to focus on guiding the learning activity, which is primarily about science, rather than teaching pupils how to use the software. His preparation enabled him to keep pupils on task by asking challenging questions and moving them on to consider other areas and relationships. Inevitably, though, some groups did need some support with both the science and ICT. The teacher provided a simple set of help commands for the software, available on laminated cards. These were deliberately brief and concise and not a step-by-step guide to each operation, since the teacher felt that the pupils would learn better by exploring and appreciating the overview of the software, rather than by following specific detailed instructions.

Commentary on specific teaching points

The pupils, who were of differing abilities, needed appropriate structure and guidance to complete the tasks. The teacher tempered this structure with an appropriate level of autonomy for pupils to explore their ideas. This occasionally meant allowing groups to explore relationships which had no correlation, but which could then be used instructively with appropriate teacher intervention. The use of software facilitated this approach, since it was much easier and faster to repeat investigations with different parameters than it would have been using manual methods of analysis. The teacher was careful, however, not to allow too much unproductive exploration, by providing timely guidance, suggestions and help. For example, timely interventions were used to suggest the control of variables, e.g. *"Do you know which variable is affecting the population growth?"* and interpretation of graphical information, e.g. *"Why does the number of rabbits repeatedly go up and down?"*

Step 7 – pupils' task (iii): producing a report

After working on the software, the pupils were asked to produce a report on how they would manage the parkland and what the effects of their decisions would be on the species present. Graphical output from the software was used by the pupils in their written work, and to support their predictions and their interpretation of data.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The teacher encouraged the use of the word processing software to complete this section of the task. Pupils were familiar from other activities with techniques such as copy and paste. The pupils saved their work on the class set of floppy disks. The teacher gave these to the IT technician to print out. In other circumstances, pupils might have saved their work on to their network area and taken turns to print out their work.

Commentary on specific teaching points

The teacher reminded the class that graphs could be pasted into word-processed text and demonstrated this quickly using the large screen display.

Step 8 – teacher's summary

At the end of the unit of work the class was brought together and the activity briefly discussed. Pupils were encouraged to comment on and evaluate the reliability of the model and examine its plausibility as a realistic model of the parkland environment.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The teacher considered this evaluation of the learning activity to be an important element of the use of ICT. The class commented successfully both on the science they had learnt and on the role that ICT had played in completing the task.

Commentary on specific teaching points

The teacher encouraged contributions from all groups by directing appropriate prompts and questions to each group. His questions ranged from those that could be answered by reference to the shapes of the graphs, e.g. *"How do you know that the number of badgers dropped?"* to those that invited pupils to consider the relationships between variables, e.g. *"How does the % coverage of grass affect the number of rabbits?"*. At this point, the teacher reviewed what pupils had learned to ensure that the teaching objectives had been met.

Possible development of the activity for the teacher to use with future classes

In the case study described above, the teacher had used a pre-prepared model. He decided that in the future he might like to create his own sample file(s) for pupils to use in a particular environment, e.g. through a spreadsheet. He realised that this would require him to develop his own IT skills further. For example, he would have to learn how to enter formulae, how to graph, and how to create macros and buttons. He felt that this extension of the activity would not only improve his IT skills and expand the range of teaching resources he could use, but it would also consolidate his understanding of the science involved in the task.

Case Study 2 – Materials and their properties

Investigating rates of reaction

This is an example where the teacher used data logging equipment to provide pupils with a rich set of data, enabling them to consider the changes that occurred during a chemical reaction in much more detail than would have been possible with a traditional approach to the same experiment. The unit of work described took place over one 70-minute lesson, spent in a laboratory.

Teaching Objectives for the unit of work

For pupils to:

i. learn that the rate of reactions can be altered by varying the concentration;

ii. investigate how the rate of reaction changes during the reaction;

iii. consider alternative ways of measuring a rate of reaction;

iv. relate the changing reaction rate to particle collisions.

Pupils' National Curriculum references

This case study focuses on the following areas of the pupils' National Curriculum for secondary science:

Key Stage 4

Materials and their Properties

3. Patterns of behaviour: rates of reactions

l. that there is great variation in the rates at which different reactions take place;

m. how the rates of reactions can be altered by varying temperature or concentration, or by changing the surface area of a solid reactant, or by adding a catalyst;

n. that reactions can occur when particles collide;

o. that increasing the frequency or energy of collisions between particles can increase the rates of many reactions.

Introduction

Class practical activities looking at the factors that affect the rate of a chemical reaction are well known, and included in all chemistry textbooks. The idea of using data logging to enhance the activity is also well documented (see e.g. *Enhancing Science with IT - Classroom Activities NCET 1994*). The reaction between sodium thiosulphate and hydrochloric acid is often used, since the equipment is simple and easy to assemble, and only a relatively cheap light sensor is required to collect the data. Whenever data logging is considered, it is important to identify clearly what advantages it offers over the equivalent manual approach. The reaction produces colloidal sulphur, making the solution go cloudy. The manual approach is usually to ask pupils to note the time taken for a cross on a piece of paper to disappear when viewed through the beaker containing the reactants: i.e. the conventional approach produces a single item of data. The computer-aided approach provides a graph that gives a complete record of the transmission of light through the solution during the reaction. So although the time taken to conduct the experiment is the same in both cases, the computer-aided approach provides a much richer set of data, enabling pupils to consider in more detail the changes occurring during the reaction. A major role for practical work of this type is to help pupils to link their concrete experiences while conducting practical work with the abstract ideas and concepts of science. In this case, those abstract ideas concern the relationship between the rate of reaction and factors affecting collisions between particles. The data analysis tools available when using the computer-aided approach encourage pupils to probe changes in the rate of reaction; the teacher can then use their findings to discuss possible explanations in terms of particle collisions.

Background information and notes

i. This unit of work was carried out with a Year 10 GCSE group

ii. In this case study the activity was carried out in a school laboratory. The teacher had access to one data logger only, which she used as a demonstration tool with pupils. This teacher was confident and experienced in using data loggers. However, even inexperienced users of ICT in the classroom might choose to use this approach, since the whole lesson does not rely on the ICT and only one computer has to be set up.

[A major constraint on the use of data loggers in investigating the rate of chemical reactions is the amount of data logging equipment available in a science department. There are various ways to organise the activity depending on the availability of resources. The ideal approach would be for the whole class to use data loggers simultaneously in place of conventional practical work. Few schools have enough computers or data loggers to do this, although some are experimenting with the use of cheaper 'palmtop' computers connected to data loggers. If there are enough data loggers and computers for half a class (working in groups of two or three), one half of the class can use the computers while the other can do the experiment using conventional equipment, and they can swap over halfway through the lesson. However, this approach needs careful planning and timing, and is a difficult option for teachers new to data logging. If the science department has only one data logger, it can be used as a demonstration tool. Well-presented demonstrations are in themselves an effective teaching tool, but when used in conjunction with data logging they become even more powerful. In this lesson, the demonstration was used after the class had carried out the experiment using conventional equipment.]

iii. As with all practical work, the teacher needed to have a clear understanding and knowledge of the equipment to be used and of the safety issues involved, and to make a risk assessment. In terms of the ICT, the teacher was familiar with how to connect the data logger to the computer and how to configure the software for the particular data logger in use. For an effective demonstration, familiarity with the software was vital, and the teacher did not underestimate the time needed for this. For example, she needed to know how to change the timescale for data collection, how to use the zoom facilities, how to use the cursors to read data from the graph and how to use the analysing tools to measure the gradient of the line.

iv. Using a single computer to display data for a whole group can be problematic. This teacher used a computer with television output. Another solution would have been to use an interface that allows a computer to be connected to a large TV (the quality is usually not good, but sufficient for observing graphs). A better, but more expensive, solution would have been to use a video projector or a LCD panel in conjunction with an overhead projector.

v. The pupils did not need to use their IT skills for this lesson, but the demonstration acted as an introduction for them to using analysis tools in data logging software, which they might have the opportunity to do at a later stage – especially those going on to study science at A-level.

vi. The data logging equipment was checked by the science technician before the lesson started.

Sequence of work in order to meet stated teaching objectives

N.B. The unit of work is set out in logical steps. In this case, all the steps took place during one lesson.

Step 1 – introduction

The topic was introduced to the class. They were told that they were to find out more about the factors that affect the rate of a chemical reaction.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The teacher did not use ICT for the introduction, which she judged could be done most effectively using a conventional approach. She wanted an interactive session with the whole class, and it was not necessary to project or display any computer-generated images to support this activity.

Commentary on specific teaching points

The teacher led a question-and-answer session, exploring pupils' ideas about reactions. The teacher posed questions such as: *"Do you think concrete will set faster in hot weather?"*, in order to elicit their ideas about factors likely to change the rate of reaction.

Step 2 – using the conventional practical approach

The teacher introduced the conventional practical activity to the pupils. They were shown how to use the equipment and how to make up different concentrations of sodium thiosulphate.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

No ICT was used at this stage since the teacher wanted the pupils to observe a conventional approach to this experiment, so that they could compare it with the later demonstration (Step 4) of the same experiment using a data logger.

Commentary on specific teaching points

The main aim here was for the pupils to understand the activity. The teacher showed pupils the equipment to be used and how it was to be assembled, and highlighted where problems in conducting the experiment might arise. She was careful not to tell the pupils what would happen in the experiment.

Step 3 – class practical activity

The pupils conducted the conventional experiment, noting the relationship between the time taken for the cross to disappear and the concentration of the solution.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

Having experienced the conventional approach to measuring rate of reaction, the pupils were in a better position to be critical of the method they had used and to appreciate the advantages of the data logging approach.

Commentary on specific teaching points

The teacher's role was to circulate, encouraging pupils to consider reasons for the changes they saw and also to discuss any problems associated with measuring rate of reaction in this way, e.g. *"Is it easy to tell when the cross has disappeared?"*

Step 4 – introducing the data logging equipment

Pupils cleared away their equipment and moved to the front bench. The teacher showed them how, when using the data logging equipment, a light source and a light sensor had replaced the 'cross' and their eyes. She also showed them how the light sensor was connected to the data logger and the logger to the computer.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The teacher now focused on using ICT to conduct the experiment, by demonstrating the reaction to the whole class with the data logger. Introducing it in this way allowed a comparison of the two methods to be made.

Commentary on specific teaching points

The teacher wanted pupils to appreciate that the method of data collection was the only difference between the two experiments. The teacher held the sensor towards and away from the light source while setting up the apparatus and showed the effect of this on the screen. She decided to assemble the data logging equipment in front of pupils rather than have it pre-assembled, because that enabled pupils to appreciate the different elements of the data logging system.

Step 5 – collecting data

The teacher demonstrated the reaction using the same concentration of reactants as was used by the pupils in their experiment. As the reaction proceeded, a line graph simultaneously appeared on the screen.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

This combination of reaction chemistry and on-screen data is a powerful connection of visual images. Pupils were in a position to compare their earlier experiment to the equipment connected to the data logger. They could appreciate how crude their method was, as well as the complexity of the reaction.

Commentary on specific teaching points

As the graph appeared on the screen in real time, the teacher described how the graph represented the changing light intensity over time. She made sure that pupils were able to relate the reaction they could see in the flask to the graph appearing on the screen. She also encouraged pupils to predict what would happen next on the graph as a result of what was happening in the beaker.

Step 6 – measuring the rate of reaction

At the end of the reaction the teacher asked pupils to compare the time taken for the cross to disappear with the graph of light transmitted against time. The teacher showed pupils ways of analysing the data. She moved the cursor across the graph while displaying the data in the form of a bar graph to provide a visual replay of the reaction.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

Non-linear relationships are complex and difficult for pupils to understand. The computer graph and software facilities provided a powerful tool to support the teacher while she discussed this with the class. The teacher was able to demonstrate the ways in which the software could be used to extract data from the graph. This allowed her to discuss the relative merits of 'instantaneous' and 'average' measures of the rate of reaction with pupils. It also served as an effective introduction to some of the tools available in data logging software.

Commentary on specific teaching points

The teacher discussed the meaning of 'rate of reaction' with pupils. They considered questions such as: *"How long does it take for the reaction to start?"; "When does the reaction finish?"; "How does the rate of reaction change?"; "Where should we measure the rate of reaction?"; "How should we measure the rate of reaction?".*

Step 7 – collecting data from the computer screen

Through discussion with the class, the teacher established a procedure for measuring the rate of reaction from the graph. Two pupils volunteered to use the software to carry out the measurement.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

By observing the measurement of the rate of reaction, the pupils became aware of the functions of ICT in measuring it, and thus developed their understanding.

Commentary on specific teaching points

The teacher felt that it was important to involve pupils during the demonstration and so wherever possible she invited individual pupils to operate the computer and to read values from the screen.

Step 8 – predict, observe, explain

The teacher then asked pupils to predict how a new graph would look if a different concentration were used. (To help them, pupils had their original graph and time taken for the cross to disappear).

Once they had done this, the data was collected using the new concentration. The original line was left on the screen and the new data overlaid on the graph. The pupils compared their sketch with the new on-screen graph.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The teacher found that the use of predict, observe, explain (POE) was particularly effective in conjunction with data logging, since the results are presented so soon after the prediction and the computer presents the results rather than expecting pupils to arrive at a 'best fit' line which would require them to set aside their preconceptions. Some software will not support the overlay of several sets of data. An alternative would have been to use a whiteboard pen to draw the original graph on the screen before collecting the second set of data.

Sketch graphs followed quickly by the actual data on the computer screen proved an effective way of encouraging pupils to engage with the activity.

Commentary on specific teaching points

The teacher was keen to stress the added value gained from the graphical information, and consequently prompted pupils to think about the shape and steepness of the curve in addition to the end point of the reaction. An interesting discussion ensued about whether the curves would all end at the same point. The teacher took this opportunity to suggest that pupils should think about the reaction in terms of the molecules involved in the reaction.

Step 9 – concept development

The previous discussion led into an explanation by the teacher of the idea of collisions using the analogy of dodgem cars at a fairground - the more cars in use, the more likely they are to bump into each other.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The visual representation of the reaction in the form of the graph was valuable in helping pupils to develop a link between their practical experiences and an abstract conceptual understanding.

Commentary on specific teaching points

The graph on the computer screen provided a common reference point, and the teacher was able to discuss with reference to the on-screen graph how a collisions model fitted with the changing reaction rate with prompts such as, *"If the thiosulphate is more concentrated, what does that tell us about the number of ions available?"*.

Possible development of the activity for the teacher to use with future classes

The demonstration approach minimised the classroom management demands on the teacher required by the ICT, and also made ICT less of a central part of the lesson. In future, the teacher might wish to use data loggers as part of a class practical. Depending on the resources available, this could mean simply setting up a data logger as a single station in a circus of experiments, or (as discussed in the introduction) allowing part of the group to use data loggers while the rest use conventional equipment. In either case, both teacher and pupils would need time to build up their expertise in the use of data loggers and in particular of data logging software. The teacher would need to identify how much previous experience pupils had had in using the software, and tailor the activities appropriately.

Case Study 3 – Physical Processes

Planets and the Solar System

This is an example where the teacher chose to make use of ICT to support, complement and enhance the conventional approach to teaching a topic on space. The unit of work described took place over three 70-minute lessons.

Teaching Objectives for the unit of work

For pupils to:

i. know the names of the planets and their position relative to the Sun;

ii. know that planets orbit the Sun and that the time for the orbit increases with distance from the Sun;

iii. know that the force of gravity holds the planets in their orbit around the Sun;

iv. distinguish between the four rocky planets closest to the sun and the large gaseous planets further away.

Pupils' National Curriculum references

This case study focuses on the following areas of the pupils' National Curriculum for secondary science:

Key Stage 3

Physical processes

The Earth and beyond: the solar system

p. the relative positions of the Earth, Sun and planets in the solar system;

q. that gravitational forces determine the movements of planets around the Sun; …

Introduction and background

i. This unit of work was carried out with a Year 8 group.

ii. The group had already completed work on the Earth and the Sun (days, seasons and the year); and on the Earth and the Moon (phases and eclipse).

iii. At KS3, as part of work on "The Earth and beyond", pupils need to understand the structure of the solar system, the relative size and position of the planets, and basic ideas about the movement of the planets round the Sun. This is a difficult topic to handle, since the dynamic nature of planetary motion makes significant demands on a teacher's powers of explanation and on pupils' ability to understand. In this instance, the teacher was aware that her pupils usually had high expectations when starting this topic, but that these were rarely met in practice. She thought that ICT would offer a number of opportunities to enhance teaching and learning and to make the topic more stimulating and exciting.

iv. Rather than replacing the conventional resources, such as pictures, video clips and models, that she normally used when teaching this topic, the teacher decided to enhance them by the use of simulations and striking images (e.g. from the Hubble telescope) obtained from the Internet. She also planned to use animations on CD-ROM to provide 3-D views of the relative motion of the planets. Later in the topic she planned to use spreadsheets to provide opportunities for pupils to manipulate simple data on planets, thus extending their skills of interpreting data, drawing conclusions and looking for patterns.

v. The teacher had access to a single computer in her science laboratory and could bring in two or three more computers if required, for example for data logging activities. However, in this case, since no science equipment was involved and it was important that all pupils had access to a computer, she decided to book the school's computer room for this session. This provided her with the opportunity to use a large screen TV for display to the whole group and to provide one computer between two pupils for the ICT-based activities. She was aware of the pressure on this room, so she made her booking well in advance.

vi. The teacher knew how to install and run appropriate CD-ROMs. She was familiar with the search facilities and could use them to identify specific material about the solar system. She knew how to enter data into a spreadsheet and understood how to use the software options to produce graphs, e.g. to explore relationships between the time taken for a planet to orbit the Sun and its distance from the Sun.

vii. Pupils already had some experience in mathematics lessons of finding relationships between sets of data using a spreadsheet, e.g. by plotting graphs. This was the first time that they had used a spreadsheet in science.

Sequence of work in order to meet stated teaching objectives

N.B. The unit of work is set out in logical steps. In this case, all the steps took place during one lesson.

Step 1 – prior knowledge

Although the pupils had already completed work on the Earth and the Sun, and on the Earth and the Moon, the teacher was aware that some misconceptions often persist, so she reviewed the main points that pupils had covered so far. In introducing work on planets and the solar system she was aware that misconceptions about the relative sizes of the Sun and the planets were likely to occur, as well as problems of identifying the Sun as a star. The teacher was unsure what prior knowledge pupils would have about the structure of the solar system and the motion of the planets. Consequently she gave pupils a few prompt questions, such as: *"What is the difference between a planet and a star?"*; "*In what way does the Earth move in space?"; "What planets are there in the Solar System, and do these planets move?"*. She encouraged pupils to use diagrams in addition to text to help them express their ideas. She did this so that she could identify pupils' initial ideas and also to enable pupils to compare their ideas after completing the topic with those they had expressed at the start.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

The teacher felt that it was not appropriate to use ICT at this stage, since the activity could be done just as effectively using a conventional approach.

Commentary on specific teaching points

There is evidence that pupils of this age are moving towards the accepted scientific view of the Earth in space and that teaching is a significant factor in the development of these ideas. The teacher felt that it was important to monitor the stage that pupils had reached in this process so that she could deal with any misconceptions held by individual pupils.

Step 2 – structure of solar system

The teacher decided to begin by discussing the orbit of the Earth around the Sun, linking it with work that this group had done earlier. Referring to diagrams in the pupils' textbook, she explained that there are eight other planets at differing distances from the Sun. She felt that it was important to explain the difference between a star (e.g. the Sun) and planets. The next step was to give pupils an understanding of the movement of the planets and their relative distances from the Sun. She decided that an animated sequence from a CD-ROM would assist this understanding in a way not possible using a static image. Using a large TV display, with some pupils watching the computer monitor, she ran the animated sequence and associated commentary. She then turned off the sound on the commentary and ran sections of the animation, going over with pupils the main teaching points for each section, e.g. the direction and speed at which each of the planets orbited the Sun. At the planning stage of the lesson, the teacher had found a number of CD-ROMs which contained similar animated sequences, but she had rejected some since she judged the content and language level too difficult for a Year 8 group. However, she had found one other CD-ROM containing an animated sequence that was slightly different from the first. She decided to show this second sequence too, since she felt some pupils might be able to visualise the motion of planets better by seeing a different presentation. She had also found a sequence on one of the CD-ROMs that discussed the way in which the pull of gravity held the planets in their orbits, and she used this to help introduce pupils to the idea that without gravity the planets would move in a straight line.

The teacher decided that if the demonstration was to be effective in promoting learning it needed to be followed by an activity in which pupils were required to engage with the idea of orbiting planets. She considered asking pupils to make a scale model of the solar system using plasticine, but decided that this would be rather time-consuming. Instead she decided to create a directed activity related to text (DART) that would require pupils to think about the distance from the Sun and the speed at which each of the planets orbited the Sun. Pupils were asked to use information provided in the form of text to construct a table giving comparative data on the planets. The information included a list of the planets in order of distance from the Sun, and, for each planet, its appearance, its distance from the Sun and the time it takes to complete one orbit round the Sun. She felt that extracting data from the text and locating it in the grid outline she had provided would be fun and encourage pupils to think about the data.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

Static pictures fail to provide any sense of the 3-D and dynamic nature of the solar system. Animations on CD-ROM have the added advantage that the sequence can be repeated, paused, and sections of it replayed much more easily than videotape. The animated sequences were shown to the whole class. The teacher used an interface that allowed the classroom computer to be connected to a large TV, as well as to the computer monitor. The quality of the display on a TV used in this way is usually not good, so she had carried out a trial run to make sure that the picture quality was acceptable for her purposes.

Commentary on specific teaching points

Pupils need to create a mental model to support their understanding of the movement in the solar system. Seeing moving images is a powerful way to support this process and complements other teaching approaches. To support this process further, the teacher asked pupils to think about this rotating disc of planets, all moving in the same direction but with those furthest away travelling more slowly. *"Picture what happens to Mercury, then think about Jupiter"*. She then replayed some of the

animation.

Step 3 – planets

The teacher then wanted pupils to find out more about the planets. She decided that the task for each group would be to produce a factual travel agent's brochure about one of the planets. She divided the class into nine groups of three and allocated each group a planet to research. On the board she provided pupils with prompt question such as: *"How warm is your planet?": "Is there anything interesting to visit?": "How long will it take to get to your planet?".*

Previously, with the help of the school's IT co-ordinator, she had used a software utility to download some Web pages on planets from the NASA Web site. This had been achieved more quickly by using a mirror site in Cambridge (http://www.ast.cam.ac.uk/Pictures/planets/). These pages had been loaded on the school's computer server and were now available at each computer terminal. The nine groups were each allocated to a computer and the Web page information was supplemented by astronomy books borrowed from the school library. A further two computers gave access to the CD-ROMs used earlier, and one other computer provided a live link to the World Wide Web. She had previously stored a list of appropriate bookmarks on this computer's Web browser so that pupils could quickly reach a number of relevant sites. During the lesson the groups were all given time at each of these three supplementary computer stations.

The teacher had to decide whether to ask the pupils to produce their holiday brochure using a word processor or on paper. Since all the pupils were working at a computer it would be easy for them to cut and paste images from the CD-ROMs and Web pages into their report. However, she felt there was a danger that they would simply 'grab' chunks of text and not read or understand what they included. She was also concerned that the activity would take too long, since the most important element was for the class to appreciate the similarities and differences between the planets. To facilitate this she wanted to allow time for pupils to share their work with the rest of the class through brief presentations. Consequently, she asked pupils to produce their brochure in note form on paper so they could use this information in their presentation to the rest of the class.

She wanted this activity to lead into the next stage by illustrating the need to look more systematically at the similarities and differences between the planets. She made the point that, because each group had looked at one planet, they were not able to compare their planet to the others.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

Pupils generally enjoy the opportunity to explore secondary sources, and it fulfils requirements for Systematic Enquiry in the pupils' National Curriculum. The teacher decided to combine conventional materials that she had used successfully in the past with ICT-based materials. She felt that this combination of resources would motivate her pupils and provide extension material. She felt that the data on the chosen CD-ROMs was well presented and motivating. This teacher had the option of using a live Internet connection. However, since she was aware that it might be slow or unreliable, she was careful to provide a number of other sources of data in addition.

Commentary on specific teaching points

The decision to incorporate ICT-based resources in addition to the conventional material was made because she felt the multimedia presentations on the CD-ROMs would be more stimulating and might assist learning for those pupils who found it difficult to form 3-D mental images and so understand the relative motion of the planets. While there is no particular need for the source to be the latest available, the material obtained from the Internet does contain some stunning visual images and consequently is likely to be very motivating for pupils. The teacher was aware of the care needed when deciding to use ICT-based material from the Internet or on CD-ROM, since often the coverage and level of language is aimed at an adult audience. For example, the general CD-ROM encyclopaedias she had chosen were not specifically aimed at Key Stage 3 pupils; however, in this case the material on the solar system was presented in a way that she felt they would be able to understand. She had rejected some CD-ROMs that specifically target this area of the curriculum, since they provided a more sophisticated coverage than she felt was suitable for this age group. The Web sites she had identified were more varied, so she decided to monitor this computer more closely during the session and help pupils where she felt it appropriate.

Step 4 – looking for patterns

The teacher wanted pupils to compare directly some simple data on the planets. To help them, she had set up a spreadsheet containing the data she wished them to handle in a format she felt was most likely to be understood. For example, the mass of the Earth was set at 1 and the mass of all the other planets was expressed in terms of this figure. Pupils could do the majority of these comparisons very effectively by using a spreadsheet to present data in the form of a bar chart.

Since the class was in the computer room, it was easy for them to load the file created earlier by the teacher. She was also aware that these pupils had used a spreadsheet earlier in the term in their mathematics lessons, and so did not need to start with an explanation about spreadsheets. She initially asked pupils to produce a bar chart comparing each of the sets of data on the planets. Pupils were asked to write a few lines explaining what each chart told them about the different planets. For example, variations in surface temperature show a fall for planets more distant from the Sun, but the value for Venus does not fit this pattern. She took this opportunity to talk about the greenhouse effect. As the lesson progressed she took the opportunity to encourage the more able to compare two sets of data, such as orbit time and distance from the Sun, using a scattergraph.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT

Spreadsheets provide an excellent opportunity to develop pupils' skills in interpreting data, drawing conclusions and looking for patterns. The level of detail in the spreadsheet can be adjusted to cater for a wide range of ability levels. ICT is particularly effective in enabling pupils to analyse much more data than would be possible by conventional means.

Commentary on specific teaching points

The teacher's decision to create the spreadsheet file before the lesson, rather than allowing pupils to construct it during the lesson, was made for two reasons. Asking pupils to enter the data would have been time-consuming and would have reduced the lesson time available for analysis; possible errors in data input by the pupils would have caused problems when it came to interpreting the data.

In addition to the advantages discussed earlier, the use of spreadsheets enables pupils to explore 'blind alleys' without the expenditure of time usually needed without them. Pupils could have been presented with a series of printed-out graphs, but the teacher considered that the use of the spreadsheet would be much more stimulating and motivating.

Step 5 – oral presentations

As a summary of the lesson, the pupils gave a brief oral presentation of the information they had collected about their planet, and were encouraged to use the data and graphs from the spreadsheet activity to illustrate the points they made.

Teacher's decisions about whether or not to use ICT in meeting the teaching and learning objectives and justifying and explaining any use of ICT.

The pupils presented their findings orally, but most groups held up printouts of graphs to illustrate particular points. The presentation could have been created using ICT, but this would have demanded more time, and the teacher judged that this could not be justified in meeting the teaching objectives.

Commentary on specific teaching points

The pupils enjoyed this part of the lesson. The presentation allowed them to demonstrate to the teacher and their peers what they had learnt, and provided a good opportunity for the teacher to assess their understanding and whether her teaching objectives had been met.

Section Four

Further Useful Information: Secondary Science

This section lists other sources of examples of the use of ICT in teaching secondary science, together with some addresses, to help trainers obtain further useful information and advice.

Publications available from the Teacher Training Agency
Publications line: 0845 606 0323

Initial Teacher Training National Curriculum for the use of Information and Communications Technology in subject teaching TTA 1998
[Annex B of DfEE Circular 4/98]

Initial Teacher Training National Curriculum for primary science TTA 1998
[Annex E of DfEE Circular 4/98]

Initial Teacher Training National Curriculum for secondary science TTA 1998
[Annex H of DfEE Circular 4/98]

Publications available from the Department for Education and Employment
Publications line: 0845 602 2260

DfEE Circular 4/98: Teaching: High Status, High Standards 1998

Publications available from the British Educational Communications and Technology agency (BECTa)

Publications line: 01203 416669

Information Technology in English Schools: a commentary on inspection findings 1995/96
NCET/OFSTED 1997 £3.95 ISBN: 1 853 794 066

Approaches to IT capability: Key Stage 3 NCET 1995 ISBN: 185379323X

This set consists of a handbook that gives guidance on implementing and assessing IT and nine subject-specific booklets, including science: available in English and Welsh.

Enhancing science with IT NCET 1995 ISBN: 1853793337

Information Sheets

- Modelling in Science
- Science and the Internet
- Exploring Experimental Data with IT
- Spreadsheets in Science
- Data Logging Software in Science

Available on the Internet at: vtc.ngfl.gov.uk/resource/cits/science/infosheets/infoind.html

Publications available from the Association for Science Education

IT in Secondary Science ISBN: 0-9520267-2-8 Updated annually.

Data Logging and Control 1997 ISBN: 0-9520257-1-X

Software for Teaching Science 1998) ISBN: 0-9520257-5-2

Datalogging in Practice 1998 ISBN: 0-9520257-4-4

Models and Modelling in Science Education 1993 ISBN: 0-8635720-3-0

Science across Europe
Enables pupils in different countries to exchange knowledge and ideas about science.

Further information is available on the Internet at www.ase.org.uk or by calling ASE on the number given overleaf.

Journals

Subject-specific periodicals and journals and the educational and national press include articles on the use of ICT in secondary science teaching from time to time. The following may be particularly useful:

The School Science Review ASE (quarterly)
Contains a regular section on resources for ICT in science.

Useful Web sites

- National Grid for Learning (NGfL)
  National Grid for Learning – Learning Resource Index of Web sites
  The NGfL is the national focal point for learning on the Internet.
  Web site: www.ngfl.gov.uk

- Virtual Teacher Centre (VTC)
  Web site: www.vtc.ngfl.gov.uk

- Virtual Teacher Centre conferencing site
  Web site: www.forum.ngfl.gov.uk/cgi-bin/WebX?vtc

- BECTa's educational software database
  Web site: www.vtc.ngfl.gov.uk/resource/esr

- BECTa CD-ROM reviews
  Web site: www.becta.org.uk/projects/cd-roms/

Organisations to contact for advice on the use of ICT in secondary science teaching

Association for Science Education (ASE)
College Lane Hatfield Hertfordshire AL10 9AA
Tel: 01707 267411 Fax: 01707 266532
E-mail: ase@asehq.telme.com Web site: www.ase.org.uk

http://www.tta.gov.uk/teaching/ict/exemplification.htm downloaded 15/12/03

General contacts for the use of ICT in subject teaching

British Educational Communications and Technology agency (BECTa)
Milburn Hill Road Science Park Coventry CV4 7JJ
Tel: 01203 416994 Fax: 01203 411418
E-mail: Becta@becta.org.uk Web site: www.becta.org.uk

Information Technology in Teacher Education (ITTE)
c/o Moira Monteith School of Education Sheffield Hallam University City Campus Pond Street
Sheffield S1 1WB
Tel: 0114 272 0911
E-mail: m.c.monteith@shu.ac.uk

National Association of Advisers for Computers in Education (NAACE)
PO Box 60 Tipton West Midlands DY4 0YS
Tel: 0121 530 9732 Fax: 0121 530 9732
E-mail: mikesmith@rmplc.co.uk Web site: www.naace.org

Qualifications and Curriculum Authority (QCA)
29 Bolton Street LONDON W1Y 7PD
Tel: 0171 509 5555
E-mail: info@qca.org.uk

Teacher Training Agency (TTA)
Portland House Stag Place LONDON SW1E 5TT
Tel: 0171 925 3700 Fax: 0171 925 3792
E-mail: tta@gtnet.gov.uk Web site: www.teach-tta.gov.uk

Notes of additional useful contacts
(e.g. LEA intranets, partner school Web sites, discussion group and conference sites)