Use of ICT to Support Science Teaching and Learning

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ABSTRACT

So far, this review has attempted to summarise the differing perspectives of the aims of science education and the significant choices that have to be made of what and how we teach. Currently, the curriculum is still driven by the agenda of the professional scientific community with a well-established pedagogy which is primarily based upon transmission of predefined, value-free content knowledge. However, the demands for change embodied in new curricula such as 21st Century Science will require teachers to adapt and adopt a different set of pedagogic practices. Its goal of fostering 'scientific literacy' involves developing a knowledge not only of the broad explanatory themes of science but also of some of the discourse and practices of scientists, including the processes of theory construction, decision making and communication, and the social factors that influence scientists' work, albeit highly simplifie,Another force for pedagogic change in science education is the new modes of enquiry afforded by computer-based tools and resources, now known collectively as 'Information and Communication Technologies. The advent of this educational technology, and its more widespread access in schools, potentially has an important part to play in re-shaping the curriculum and pedagogy of science. In particular, it offers easy access to a vast array of internet resources and other new tools and resources that facilitate and extend opportunities for empirical enquiry both inside and outside the classroom. Thus, in a very real sense, it offers opportunities to dissolve the boundaries that demarcate school science from contemporary science by facilitating access to a wide body of data, such as real-time air pollution measurements, epidemiological statistics, or providing direct links to high quality astronomical telescopes, and providing ready access to a wealth of information about science-inthe-making.

Access to such secondary resources and data, however, places greater emphasis on the need to provide a science education which gives pre-eminence, as its ultimate goal, to developing the higher order cognitive skills of evaluation and interpretation of evidence requiring critical assessment of the validity of theories and explanations. Such an education would seek to support and develop students scientific reasoning, critical reflection and analytic skills. What, then, is the potential of using ICT to support and nurture such a science education? In the following sections of this review, we now examine this potential – particularly that envisioned by the current trend in science education which seeks to develop scientific literacy. We also explore the teacher's role in exploiting this potential and the outcomes. so far, concluding with a consideration of the implications for further development.

The use of graphing or modelling tools provides dynamic, visual representations of data collected electronically or otherwise. Like the interactive simulations described above, use of

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these tools offers immediate feedback to pupils, and introduces a more experimental, playful style in which trends are investigated and ideas are tested and refined. Through ICT providing an immediate link between an activity and its results, the likelihood is increased that pupils will relate the graphical or diagrammatical representation of relationships to the activity itself. In particular, the key pedagogical technique of Predict – Observe – Explain is greatly facilitated through viewing a graph or model on screen soon after making a prediction.

The potential role of ICT in transforming teaching and learning Classroom use of ICT became a statutory requirement in all subjects with the introduction of a National Curriculum in 1989. This obligation has been somewhat elaborated with successive curriculum documents but its role is described in broad terms, in the form of tentative notes in the margins of the Science National Curriculum. opportunities' in the curriculum include pupils could use simulation software to investigate and model circuits and pupils could use data loggers to investigate relationships. Currently, the curriculum is still driven by the agenda of the professional scientific community with a well-established pedagogy which is primarily based upon transmission of predefined, value-free content knowledge. However, the demands for change embodied in new curricula such as 21st Century. Science will require teachers to adapt and adopt a different set of pedagogic practices. Its goal of fostering 'scientific literacy' involves developing a knowledge not only of the broad explanatory themes of science but also of some of the discourse and practices of scientists, including the processes of theory construction, decision making and communication and the social factors that influence scientists' work, albeit highly simplifie,Another force for pedagogic change in science education is the new modes of enquiry afforded by computer-based tools and resources, now known collectively as ICT. The advent of this educational technology, and its more widespread access in schools, potentially has an important part to play in re-shaping the curriculum and pedagogy of science. In particular, it offers easy access to a vast array of internet resources and other new tools and resources that facilitate and extend opportunities for empirical enquiry both inside and outside the classroom. Thus, in a very real sense, it offers opportunities to dissolve the boundaries that demarcate school science from contemporary science by facilitating access to a wide body of data, such as real-time air pollution measurements, epidemiological statistics, or providing direct links to high quality astronomical telescopes and providing ready access to a wealth of information about science-in the-making for using ICT. The established model of using ICT to support school science assumes an iterative, investigative approach, as embedded in the National Curriculum, and incorporates simultaneous learning about scientific theory and praticals. The main forms of ICT which are relevant to school science activity include:

Tools for data capture, processing nand interpretation data logging systems, data analysis software, databases and spreadsheets, calculators,graphing tools, modelling environments Multimedia software for simulation of processes and carrying out virtual experiments'- CD-Roms, DVDs.

Information systems

CD-Roms (eg 'Encarta'), internet, intranet Publishing and presentation tools, Digital recording equipment – still and video cameras Computer projection technology interactive whiteboards,data projector, screen, external monitor or TV. The first category of tools – those which can support practical activities or scientific enquiry – is currently the most significant form of ICT application for science teaching and learning. Its centrepiece is the data logging system, comprising a set of sensors or probes to convert the quantity to be measured into a voltage recognisable by the computer; an interface to pass information from sensors to computer; and a computer program to control the interface and presentation of data on the screen. Sensors can be used remotely for collecting data over time from outside the laboratory, for example for monitoring weather. The versatility of the data logging system means that it can be used within a range of activities to support any of the substantive curriculum areas of study.

Multimedia software may include video and audio explanatory sequences, animated graphics, tutorials or interactive tasks, slide shows and/or an interactive database/ encyclopaedia. Some contain innovative analytic software which renders the simulated motion interactive and quantifiable; pupils can, therefore, manipulate variables or mark points and then process the data either by calculation or display in graphical form.

Some multimedia CD-Roms

Also offer a virtual microscope enabling pupils to see exactly what they should see through a real microscope. Information systems are typically used to support conceptual learning in the three substantive curriculum areas. Intranets storing a limited range of web content on a local network server are increasingly being used to provide an information resource which is safer, more quickly accessible and pre-filtered compared to the internet.

Word processing can support an iterative approach to planning or analysis and presentation tools can be used to present findings of research or investigations in any topic area. A further kind of tool is the computer-controlled microscope where still, moving or time-lapse images can be captured, labelled, enlarged etc and used in conjunction with laboratory or field work. Increasingly popular are multi-purposedigital still and video cameras. These can supply images for incorporation in teaching materials/ presentations, or experiments can be recorded by pupils themselves.

Finally, projection technology has become central to science education; access is rapidly increasing and it can be used with any of the other tools for whole class interaction – demonstration,lecturing, or collating and discussing class results. Interactive whiteboards are a special case and can encourage new forms of active student participation in science activities, as discussed later on. Other common modes of using ICT include using a single computer or data logger with a small group (eg as part of a 'circus' of rotated activities in the lab or for entering experimental results into a spreadsheet); half a class using a few machines a whole class using a computer suite or set of portable computers in the laboratory and independent use. Certain learning purposes and resource levels clearly lend themselves more tocertain modes of use and use of particular tools is associated with certain pupil learning modes, eg. receiver or revisor of knowledge, explorer of ideas, creator of reports/presentations

Drawing on some prominent examples of recent research, we now examine how the above forms of ICT can potentially enhance both the practical and theoretical aspects of science teaching and learning, and explore the uses of ICT in the school laboratory. In particular, two recent books – one by Newton and Rogers (2001) and an edited collection by Barton – offer an overview of the field as well as extensive practical guidance to teachers wanting to develop their practice in teaching with ICT. We also make use of ongoing research by the second author and her colleagues which is concerned with analysing and documenting effective ways of using ICT to support subject teaching at secondary level .

In conjunction with the wider research literature, the findings converge on the following conceptualisation of the potential contribution of technology use to science teaching and learning. Expediting and enhancing work production; release from laborious processes The use of ICT, particularly tools for data handling and graphing, can speed up andeffect working processes, notably the morearduous and routine components. This frees pupils from spending time setting upexperiments, taking complex measurements,tabulating data, drawing graphs by hand and executing multiple or difficult calculations. It enables rapid plotting of diverse variables within a short period, or collection of and comparison between a larger number of results.

Hence it is possible to significantly increase the productivity of pupils within a single lesson and improving the quality of work they produce. Using the versatile software tools which are now linked to data logging is particularly helpful in allowing pupils to explore and present data in different ways with a low investment of time and effort . Such tools free experimentation from the time constraints of the standard one-hour lesson, allowing data to be collected over several days, or even several weeks. Interactive computer simulation can help pupils to avoid getting 'bogged down' with the mechanics of simply setting up equipment, for example constructing and testing a circuit where the proliferation of wires involved can make it difficult to see what is happening, and minor faults in physical connection can pose a complete impediment.

ICT-supported procedures are not only faster and more efficient, but are also considered more precise, reliable and accurate. They yield less 'messy' data and illustrate phenomena without the 'noise' of unwanted variables and human error in measurement – in contrast with some practical experiments. Digital still and video cameras can offer high quality images of fieldwork sites, practical demonstrations or experiments. Finally, interactive worksheets can incorporate diagrams and text created in other applications. This saves time and improves accuracy by removing the need for students to copy them by hand before using them for conceptual activities. The worksheets can include automatic 'hyperlinks' allowing rapid access to pre-selected information on the internet or in an encyclopaedic database such as Encarta. Interactive whiteboards offer similar facilities and the ability for the teacher in a whole class situation to move instantly between multiple kinds of prepared resources stored on a single computer or network.

Conflicting opinions arise regarding whether time for discussion and reflection upon activity can be easier or more difficult to find when using ICT, but a 'time bonus' is commonly reported. Teaching with ICT is said to offer more time for teacher interaction and intervention with pupils and greater sharing of class results, permitting more time for pupils to observe,think and analyse rather than being preoccupied by gathering and processing data.

Thus, in this sense, ICT does create the space to develop the kinds of analytical skills demanded of contemporary science education. Moreover, in conjunction with prompt teacher intervention, real-time data display can be a powerful stimulus for discussion and interpretation, particularly where large sample sizes are involved, or complex interactions between a number of variables may be evident. Real-time data display also enables the teacher to demonstrate instantly the link between an event and its formal representation. For example, the ability to produce graphs of the motion of objects as it happens strengthens the association between the phenomenon and its scientific representation.

Conclusion:

Use of ICT changes the relative emphasis of scientific skills and thinking; for example, by diminishing the mechanical aspects of collecting data and plotting graphs particularly beneficial for low ability pupils , while enhancing the use of graphs for interpreting data, spending more time on observation and focused discussion, and developing investigative and analytic skills. Research also suggests that using computer modelling and simulation allows learners to understand and investigate far more complex models and processes than they can in a school laboratory setting. Increasing currency and scope of reference and experience Use of ICT, especially the internet, can open up access to a broader range of upto- date tools and information resources,and increase the currency and authenticity of schoolwork far beyond that which textbooks and other resources can offer. It allows pupils to relate their work more closely to the outside world to obtain live news or real data, for example concerning an earthquake. Pupils can even ask questions of 'real' scientists, or collaborate or pool results with peers Such exploration of pressing global questions promotes students awareness of environmental issues and the Earth as a dynamic system.

ICT to raise pupils awareness of the uncertainties which surround the construction of scientific knowledge, especially the validity and consequences of different scientists producing different results and interpretations. This tool can be used to support role play and group discussions of topical social and ethical issues, including media bias and oversimplification in presenting science news stories. Tools like this may,therefore, support teachers in rising to the new pedagogical challenges emerging as the curriculum begins to shift. Using ICT can provide access to new forms of data previously unavailable. Using ICT further allows teachers and pupils to observe or interact with simulations, animations or phenomena in novel ways that may be too dangerous, complex or expensive for the school laboratory. Use of a data logger can facilitate otherwise impossible demonstrations, such as measuring energy transfer as a hot liquid cools.The internet also offers some unique opportunities for pupils to experience phenomena such as viewing the Earth from a moving satellite. A particularly accessible and popular way of exploiting the power of visual representations to develop understanding – particularly of abstract phenomena like electricity flow is the direct use of video clips from interactive simulation CD Roms. Interactions with virtual phenomena can be repeated as often as necessary for the learner impossible during a live practical.

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