Chapter 7 Getting creative with technology in science

Chapter aims

By the end of this chapter, you should be able to

- Identify some of the potential applications of digital technologies to primary science teaching
- Recognise creative approaches in the use of digital technologies in science teaching
- Describe the ways in which digital technologies can be used to enhance the way in which pupils may work scientifically.

In 2013 the UK spent £595 million on ICT (information and communications technology) in schools, given that 2014 will see in excess of £600 million spent, £1 billion will have been spent in two years (TES, 2013).

Spending on equipment in schools has increased considerably with the mobile computer market, which includes tablets and laptops, contributing to the highest rise. Demand for mobile devices has also contributed to the spending rise in the UK, with 260,000 devices bought by schools in 2013, a figure up from approximately 100,000 in 2012 (TES, 2013)

This huge and impressive expenditure has presumably led to a diverse and varied range of digital technologies being available in most schools. These may range from mobile devices to smart boards and even to the less physical presence of cloud computing and digital learning platforms for schools. However, despite this outlay in digital technologies the educational charity NESTA found that such investment had not yet “resulted in radical improvements to learning experiences or attainment” Nesta (2012). Furthermore, Scotland’s Science and Engineering Education Advisory Group (2012 p. 26) state that ultimately, it is the quality of teaching that determines what pupils learn, not the quality or availability of technology.

Technology has undoubtedly had profound impacts on the management of schools and the organisation and planning of teaching. Schools may have public access websites, electronic registers, digital facilities and applications for monitoring progress, managing budgets. Teachers look increasingly to online resources and will most probably store and organise increasing numbers of classroom activities, evaluations and reports on mobile devices. In this way, the profession is almost unrecognisable from 10 to 15 years ago. A transformation in the running and organisation of schools perhaps, however, “evidence of digital technologies producing real transformation in learning and teaching remains elusive.” (Nesta, 2012)

The arrival of such technologies can present teachers with significant problems. The first and foremost is the time it may take to become familiar with the operating protocols. Once familiarised however, it also takes time to plan and integrate its effective use into the curriculum. There is an important point here. Technology alone will not have any impact on learning, it is best perhaps to think about what is an effective learning activity and explore how the use of digital technologies may further enhance that learning experience. In other words, not to see the technology as the central focus, but as additional to an already effective session and in this way continue to improve already successful learning. This also places the technology in a position where it is part of the learning process, not necessarily central to it. Too much onus on the use of technology in some cases it may even detract from learning; where for example the technology becomes of more interest and attention than the actual topic being studied. The term ‘transparent technology’ is explained in box 7.1.

[Start Box]

Time for reflection 7.1

I find television very educating. Every time somebody turns on the set, I go into the other room and read a book.

Groucho Marx

When you watch television you normally concentrate (or at least focus) on the programme that’s being broadcast. We look and listen to follow a plot line, or a line of argument, or we may simply looking at pictures or images. Television does have significant power to teach, inform as well as to entertain. However, what we rarely ever do when watching TV is to consider the technology that surrounds the images and programmes that we are watching. The technology is invisible. As such it doesn’t get in the way of story lines or narratives. How can we use technology in science teaching (and teaching generally) so that it too becomes invisible so that we, and the children, can concentrate on learning? Only then do we focus on the learning, rather then the technology.

This is referred to as transparent technology. Transparent technology is technology that does not distract from learning.

[End Box]

Connecting learning

Contemporary digital technology can provide a variety of ways to connect children in schools. They can connect to their teacher, or to other students, or to experts in particular fields. These may be real time using available tools such as Skype, or recorded on a blog, or YouTube. However, increasingly with social media applications these connections may promote dialogue. The children cease to be passive recipients of information, but become instead an active in the discourse and may explore and interrogate ideas more effectively. The role of dialogue and discussion in enabling conceptual change and its central role in effective teaching and learning in science is stressed in Chapter 2.

Digital technologies not only allow for innovative ways of presenting information but also afford unprecedented ways of sharing it, not just within the school, but also with a worldwide audience. Through networking and bringing groups together it can also provide a context for the work that potentially enhances the perceived relevance of the study and so improves the learning experience for the children. Such dialogues can take place over time, across a variety of settings and topics, and even across groups of different groups of learners, perhaps linking primary school children with university students or staff.

Collaborative work is also possible with national science organisations. For example the Open Air Laboratories Project (OPAL) looks at a new topical science theme each year. The children are asked to carry out the field work and collect the appropriate data. Past surveys have included work on worm populations, air quality and tree health. By taking part schools are provided with dedicated survey packs and the children can upload their collected data to the OPAL website (http://www.opalexplorenature.org/). The preliminary sessions, supported by the surveys website and the relevant context of the fieldwork provides an opportunity to engage children in first-hand science research, one in which they can see the usefulness of their own work. OPAL is only once of such science based projects and other suggestions are given at the end of this chapter.

Digital technology and science

Becta (2009) reported that ICT has fundamentally changed the ways in which scientists measure, handle data and access information. It also stated that it offers opportunities to extend work in the classroom and affords insights, possibilities and efficiencies that are difficult to achieve in other ways. Ofsted (2013 p.17) in the most recent report on schools successful in science reported about two thirds of the schools visited used information and communication technology (ICT) for science, and about half of these did this effectively to support the teaching of science. Most commonly, this was through teachers' use of presentation software, including multi-media pictures and clips of scientific phenomena. In a small minority of the schools visited, the pupils used ICT regularly for internet-based research themselves. It was unusual, however, for the teachers to use ICT to record and process evidence from experiments. They recognised that opportunities were often missed to use technology to help in processing data from investigations and to give direct evidence to pupils of the underlying concepts.

BECTA (2009) suggested the main applications of ICT in science as:

- providing information
- supporting fieldwork
- assisting observation
- recording and measuring
- sharing data with others
- facilitating interpretation
- simulating experiments
- providing models or demonstrations
- enhancing publishing and presentation.

Additionally, Becta's 21st Century Teacher (2010) offered exemplars on using technology effectively for teaching and learning in science for visualising different concepts, collecting data and conducting experiments. It is interesting that even as technology makes rapid advances and changes, the applications of technology in enhancing science learning remain largely similar. Some of these applications will be discussed in more detail with consideration for newer technologies.

Science and technology are often seen to go hand-in-hand and in other countries they are formally linked together through the curriculum framework, for example in Northern Ireland where children study the 'World around us' through science and technology, history, and geography (CCEA 2004). Gresnigt et al (2014) offer a critical perspective on integrated curricula. Their international review considered the effects of integrated science and technology curricula in primary school. The reported effects were overall positive with students' motivation and appreciation of science and technology reported to have increased, and most projects reporting an increase in the time spent on science. In addition, the projects generally reported positive learning results in the domain of science and technology, as well as in the domains of mathematics and language, which involve knowledge as well as higher-order thinking skills. So there is research evidence to support an integrated approach teaching science with technology.

The 2014 National Curriculum for England (Department for Education 2013) has recently seen a fundamental change to content moving from ICT towards what is described as computing science. The basic principles of computing are introduced very early with:

"Children from:

- *the age of 5 will be taught what algorithms are and how they are used in digital devices - they will also learn how to write and test simple programs and to organise, manipulate and store digital content.*

- *the age of 7, pupils will be taught to understand computer networks including the internet, and how they can provide a range of services, such as the worldwide web."*

Computer science has a far greater emphasis on the actual working of digital devices and can involve children in design and simple programming. There are a number of available devices, such as the Raspberry Pi, that will provide excellent sessions in simple programming. However, although there are potential opportunities to embed digital technologies in science sessions, it is important to look to do so not for the sake of simply introducing or becoming familiar with the technology, but to really enhance effective learning in science through sustained, creative approaches. Education Scotland (2013) report that in many schools design technology is a highly creative subject, particularly where digital skills are involved and so therefore has a particular scope for promoting creativity and learning in science. Additionally, in an earlier report on primary science, Murphy (2005) highlighted the use of ICT as a creative context for teaching science. However, this is where we note a word of caution, it is an important point that as part of the creative use of technology it becomes the medium through which learning takes place. This is an important distinction. To illustrate the use of digital technologies in science it is perhaps worth thinking of how we 'work scientifically'. In other words by looking at each stage of a science-based methodology we may identify ways in which this may be achieved.

Data harvesting with digital technology

Observation is a primary point in science and digital technologies may assist in a variety of ways. The internet is a powerful source of images that in themselves can enhance the learning experience. On a topic such as 'the solar system' the NASA website (http://www.nasa.gov/audience/foreducators/) provides astounding images of the plants as well as animations and interactive applications that allow you to explore the solar system as you move from planet to planet. The ESA website (http://www.esa.int/ESA) and other astronomy sites such as Red Orbit (http://www.redorbit.com/) all have fantastic image libraries, although private sites are prone to advertisements.

Interactive online applications such as Google Earth can be excellent teaching resources. Google Earth in particular has a number of tools that can be really useful in science teaching. The measuring tool for example allows a comparison of the relative sizes of natural features (such as the north/south extent of the Amazon rainforest compared to that of Great Britain). As distances can be measured from place to place, it may provide an excellent means of thinking about food miles. Children can simply measure and add up to calculate the distances that the component items of a meal have travelled. Returning to the solar system, Google Earth now also includes Google Mars and Google Moon, so that features such craters and mountains on these different worlds may be measured and explored in high definition.

Furthermore, nearly all aspects of the National Curriculum may be enhanced and explored through the BBC website (http://www.bbc.co.uk/schools/) as it has fantastic sets of pictures and films. Children can see high definition images of animals and plants from around the world as well as images of prehistoric life and each image comes with a full description.

As powerful and as beautiful as such images are, they may not replace first-hand field observation as a learning experience. Cheap and robust digital technology may allow the children to have their own nestbox cameras to observe nesting birds. There are a range of cameras manufactured today that are waterproof (to shallow depths) and may be placed in the school pond or in rock pools. They can produce a ‘live’ image that the children can see on a mobile device, or some can be set to take images at predetermined time intervals. If the camera is left in a rock pool and the images later run together, a simple time-lapse film may be generated demonstrating the movement that took place in the pool. There are dedicated and fairly cheap time-lapse cameras in the market at present.

Observation does not only imply visual, audio recording may be a useful. In different settings recording bird song is a way in which children can begin to explore ideas of habitat and animal association. Recording their observations in field can also be effectively done through audio recording devices, or by digital cameras. These recordings may be structured, or may simply be free images of objects that the children simply finding interesting or intriguing.

There are a range of designed for schools digital microscopes on the market that will interface directly to a mobile device and that can produce quite effective images to adequate levels of magnification. Some are even small handheld devices and the clarity and simplicity of their use is ever improving.

There are a range of relatively cheap digital devices including cameras, mobile webcams, movie cameras and so on, that can be used to enhance field and classroom observation that also afford children the opportunity to use the equipment and process the results in meaningful ways.

For more technical data collection there is a range of dedicated data loggers on the market and it is worth regularly checking out what is available as they have moved on in terms of ease of use and in relation to functions. Today many include on-board graphing and wireless sensors will readily remotely interface with mobile devices over some distance.

There is also huge potential in using other hardware tools such as the Raspberry Pi computer for collecting data. These can be quite advanced, but there are growing uses for such simple and cheap tools in primary schools, both in terms of gathering data and also presenting it. The further reading suggestions at the end of this chapter will provide you with links to some interesting introductions to this hardware and its applications in schools.

Data harvesting is one thing, but working scientifically requires the focus of a question to answer or hypothesis to test. The recording of the process of investigation by film or by audio is one good way of enhancing the activity, the film could be divided into the relevant sections of introduction, methods, results and conclusions.

However, the analysis and presentation of data may also be effectively and creatively achieved through digital media.

Presenting results: charts, graphs and infographics

The creative use of digital media can really help to enhance sessions when ordering, exploring and analysing data. There are of course the easily accessible software applications that are common to most PCs such as Microsoft Excel that can produce charts and graphs of numerical data. Although, even with these standard applications it is worth spending some time exploring how to edit charts in terms of axis settings and text. However, for children spreadsheet charts are somewhat static and are hard to see in context. The data are simply 'presented'. Pasting the charts into presentation applications such Powerpoint or Prezi allows slides that explain the activity to be included, show pictures or short films or soundtracks and may allow some limited animation of any charts or graphs.

There are however more interesting forms of so-called 'data infographics' tools that are increasingly appearing on the internet such as easel.ly and vizualize.me. Here the data can be put into context and symbols, maps, pictures may be included to build up a poster of the results.

There are a number of freely downloadable animation software, from stop-motion to explanations of producing RSA Animate style films (see further reading). Animation presents a range of creative opportunities. Certainly graphs may be annotated, but not necessarily as two dimensional charts. Stop-motion software provides an opportunity for graphs to be made from anything from modelling clay, paper, or even people. Animation also allows processes such as growth of a plant, or the evolution of an animal to be demonstrated and through such presentations the learning and understanding may be reinforced. To enhance the data in a way that actively engages children and helps them better understand is the objective of what is ultimately a creative process.

Data and analysis

One further advantage of the internet is the fact that there is a great deal of open data available. These data allow children to explore issues and science using real data. Furthermore there are some excellent sites that also suggest ways of displaying data in really meaningful and creative ways. Learning to present and understand what charts and graphical representations of data mean is a key literacy skill in science and perhaps in wider educational contexts as well.

More sophisticated methods of analysis are of course also available. Microsoft Excel and other similar spreadsheet software can sum and mean numerical data, as well as a whole range of highly sophisticated analyses well beyond primary science.

The data collected by children may not be in numerical form, but this does not necessarily negate analysis. Data may be in word forms, where children may have a written down key observations or memories of field trips, or it may be the text derived from searches for information on scientists. All text may be subjected to simple visual analysis by using 'word-clouds' generated from freely available online tools such as Wordle (http://www.wordle.net/). This particular site affords children the choice from a wide selection of designs and colours. There are many other sites, such as TagCrowd (http://tagcrowd.com/) that are perhaps less design-based, but does provide a more accurate visual representation, as it ignores certain words (such as pronouns) and can be set to ignore others. There are wide ranges of such tools and links that are presently of varying degrees of ease of use and editing control. They are generally easy to use and do provide the basis for a good deal of follow up discussion.

All forms of data need to be presented, whether numerical, visual or audio. Indeed, the presentation and communication of methods, findings and conclusions provides a perfect opportunity for creative approaches to this. Films, short documentaries, animations, webcasts are all possible using digital technologies. Of course price will be a significant constraint, so if you do have the facilities, you should really make the maximum use of them. Working scientifically involves designing inventive methods by which to collect and interrogate data and thereby answer questions. The research frontier uses digital equipment in nearly all phases of investigation and dissemination. For children's learning in science to be authentic, then perhaps, so should they.

Conclusion

Such is the rapidity of developments in contemporary digital technologies any chapter that addresses its use in schools runs the risk of being out of date before it is published. The applications that are discussed here and the links that are provided are current, however, things are changing very rapidly. So rapidly in fact that it may seem impossible to keep up. This can be a daunting for a teacher, particularly one who has the added challenge of integrating such technologies across subjects. Teacher confidence in using ICT in science was identified as a significant issue (Murphy 2005 p.45) in a report on primary science. However, it is important to remember that technology can enhance learning as part of the overall experience. The degree to which digital technologies contribute to that process is a decision of lesson design and planning, the important thing however, is that its use, whatever it may be or in what form it takes, does enhance and improve learning.

Technology has the potential to provide opportunities for collaborative work that may help contextualise any research, through networking, that opportunity may be global, pairing students with those from different countries comparing findings or results, thereby developing a community of learning.

Digital technologies certainly offer potential for teachers to explain and demonstrate through images, animations or short films and it allows teachers to structure and to differentiate their lessons more effectively. They also offer the opportunity for children to carryout different forms of scientific explorations, through the use of remote, or hand-held cameras, sound recording, wireless sensors that transmit data to the classroom. It also presents opportunities for the really creative presentation of results and conclusions that can be shared collectively online.

Science is grounded on inquiry, so the use of digital technology naturally fits with an inquiry-based approach to teaching and as such it does have very real potential in enhancing learning in science. However, the creative potential of such technologies and the possibilities that they present for children to network with others from around the world are considerable. In this book we have talked about teaching science creative contexts for, digital technologies in all their wide forms, provides just that.

Further reading

Nesta (2012) Decoding Learning: The Proof, Promise and Potential of Digital Education [On-line] Available from http://www.nesta.org.uk/publications/decoding-learning (Accessed 10.12.13)

This is also listed in the reference section of this chapter, but it is a really interesting report on the effectiveness of IT in schools, with great ideas on how to make it more so.

There is so much open data available that lets young people work with large and real data sets to explore science. There is a great deal of material in this series of blog posts: http://edu.blogs.com/edublogs/2011/03/data-reveals-stories.html

Another one: https://www.google.com/publicdata/directory

Some wonderful animated graphs of which some are science-related and some more political and could be used with older children can be found at http://www.gapminder.org/

The collection from Becta and the ASE offers a range of case studies on the effective use of technology in primary science. While the case studies are a few years old, they give an excellent picture of the range and varied use of technology and the benefits of it in primary science and they are available from:

ASE (2014) Becta Science Resources [Online] Available at:

http://www.ase.org.uk/resources/becta-legacy-science-resources/

Descriptions and ideas relating to available new hardware, that has exciting potential for primary schools are available at the following sites

http://www.briandorey.com/post/Raspberry-Pi-Solar-Data-Logger.aspx

http://www.raspberrypi.org/archives/1620

References

Becta (2009) Primary Science with ICT: Pupil's entitlement to ICT in primary science. Becta in association with the ASE [Online] Available at: http://www.ase.org.uk/documents/becta-ict-in-primary-science/

Becta (2010) The 21st century teacher: science. Using technology to enhance science teaching. [Online] Available at: http://www.ase.org.uk/documents/becta-the-21st-century-teacher-science/

Council for the Curriculum Examinations and Assessment (2004) The World Around Us. The Northern Ireland curriculum. CCEA [Online] Available at: http://www.nicurriculum.org.uk/key_stages_1_and_2/areas_of_learning/the_world_around_us/

Education Scotland (2013) Creativity Across Learning 3-18 [Online] Available at: http://www.educationscotland.gov.uk/Images/Creativity3to18_tcm4-814361.pdf

Gresnigt, R., Taconis, R., van Keulen, H. and Gravemeijer, K. and Baartman, L. (2014) Promoting science and technology in primary education: a review of integrated curricula, *Studies in Science Education*, 50(1), p. 47-84, DOI:

10.1080/03057267.2013.877694

Murphy, C. (2005) Primary science in the UK: a scoping study. The Wellcome Trust [Online] Available at: http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtx026636.pdf

Nesta (2012) Decoding Learning: The Proof, Promise and Potential of Digital Education [On-line] Available from http://www.nesta.org.uk/publications/decoding-learning (Accessed 10.12.13)

Ofsted (2013) Maintaining Curiosity: A survey into science education in schools [Online] Available at: http://www.ofsted.gov.uk/resources/maintaining-curiosity-survey-science-education-schools

SEEAG (2012) Supporting Scotland's STEM Education and Culture. Science and Engineering Education Advisory Group. Second report. The Scottish Government [Online] Available at: http://www.scotland.gov.uk/Resource/0038/00388616.pdf

TES (2013) [On-line] Available from http://www.tes.co.uk/article.aspx?storycode=6358755 (Accessed 10.12.13)