Emerging Technologies for Learning

Becta
ICT Research

Foreword

I am delighted to present this review of emerging technologies in education.

Becta plays a central role in evaluating the potential and impact of technology in education, working closely with UK Education Departments, educational institutions, industry and academia. Our aim is to understand the effectiveness of technology in addressing educational issues and supporting educational outcomes. This review, like our other work in this area, draws on a range of evidence and thinking, and presents a balanced and informed view which will help educators and policymakers to think about the future.

The review features five articles by experts on a variety of technology themes. It covers emerging technologies and some of the future trends that are likely to have an impact on education. This is not a technical document. It is intended to inform readers about the potential for technology to transform our ways of working, learning and interacting over the next three to five years.

Clearly, emerging technologies can make a major contribution to the development of a 21st-century education system – one which places learners at the heart. We are now moving from a phase of using technology to digitise existing practices and resources to one of using technology to transform them. Indeed, technology is critical in this, as it can support 'anytime, anywhere' learning, improve access to learning resources and offer collaborative, creative, dynamic and adaptive experiences that truly support personalised learning.

However, change is not simply about technology. The successful implementation of technology to support transformation involves understanding and overcoming technical, organisational, pedagogical and socio-cultural challenges. To this end, Becta is building partnerships with industry and the research community to explore innovative approaches to the effective use of technology and to gather and disseminate evidence of related benefits, effective practice and appropriate strategies for change.

I hope you will find the visions outlined in this publication stimulating, and that they will excite you about the prospect of embedded technology supporting learning when and where needed and in a way that is tailored to learners.

Andrew Pinder
Chair, Becta

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About the authors

Geoff Stead – CTAD

Geoff Stead is a director of Tribal CTAD, part of the Tribal Group plc. For the last five years he has led the development of technology resources that seek to make learning work for everyone. Originally a computer scientist, in South Africa he worked with street children and labour unions, getting them involved in computers as far back as the 1980s. Recently, he has championed m-learning and is now one of the UK's leading thinkers on this exciting theme.

Tribal CTAD **[http://www.ctad.co.uk]** specialises in developing materials that use technology but are driven by pedagogy. CTAD's key focus is to find ways of reaching people who, for whatever reason, have not been able to benefit from mainstream education in the UK.

Bill Sharpe – The Appliance Studio

Bill Sharpe is CEO and co-founder of The Appliance Studio **[http://www.appliancestudio.com]**, a research and innovation company specialising in the impact of pervasive digital technology on everyday products and services.

Bill undertakes strategic technology consulting for commercial and public-sector clients, bringing fundamental user understanding together with strategic tools for the management of innovation. Recent projects have included leading long-term technology impact analyses for two of the UK Foresight programmes: Cognitive Systems; and Cybertrust and Crime Prevention. He is a visiting fellow at the University of Bristol, where he was co-founder of a collaborative research programme exploring the interaction between located digital media and physical space **[http://www.mobilebristol.com]**. Bill was previously a research lab director at Hewlett-Packard in Bristol, where he pioneered new concepts in pervasive computing.

Paul Anderson – Intelligent Content

Paul Anderson is a computer scientist and writer. He is Technical Director at Intelligent Content Ltd, a consultancy-led business that specialises in content about, and for, new and emerging technologies. He is also Technical Editor for the JISC Technology and Standards Watch service, which keeps track of the future direction of technology and its implications for higher education. Paul has written a number of articles for magazines such as *Computing*, and is a member of the National Union of Journalists, the British Computer Society and the IEEE.

Leon Cych

Leon Cych is Editor of *Computer Education*, the professional journal for NAACE. He is also director of Learn 4 Life **[http://www.l4l.org.uk]** – a company that trials, showcases and informs the educational sector on innovative web technologies. He has an active interest in the fusion of technology and the arts, and was instrumental in staging the world's first virtual opera for King's Cross Education Action Zone – a NESTA funded project **[http://www.carmenavalook.com]**. He is currently working on building content for an extended schools initiative using the open source VLE, Moodle.

Michael Philpott – Ovum

Michael Philpott is a principal analyst at Ovum, specialising in broadband access technologies and next-generation networks. He is a leading figure in the Broadband@Ovum team carrying out research into areas of broadband technology, operator strategy, broadband markets and market forecasting. Michael is also well known on the conference circuit, providing his analytical view on broadband markets and technologies.

Ovum **[http://ovum.com]** is an analyst and consulting company that analyses the commercial impact of technology and market changes, and advises on the developments where telecoms, software and IT services interact. Its experts spot the short-term issues that will have an immediate impact on markets and organisations, and advise on the longer-term 'visionary' aspects that form the basis of strategic planning.

Mobile technologies: transforming the future of learning

Geoff Stead

Introduction

'For today's class we will be building a 3D map of the village. First, we'll collect pictures, sounds and anything else of interest from each street. Split into teams of four and take your camera-phones with you. By mid-day we will have built our own virtual map, and then we can get together to plan which parts to research further.'

'My students work for a trucking company and at any given time they are all over the country. I never see them. But whenever they have a stopover, they check in on their mobile device and we do some work together. For us, mobile learning is the only option.'

'As she cycled to class for her oral exam, she listened to the revision lecture from the week before. The entire session had been podcast, and had automatically downloaded itself onto her music player that morning.'

'As he waited for the bus to take him to his driving-theory test, he took out his phone and practised running through the questions one more time. On each of the last ten attempts he had got over 95% correct and was feeling confident about the real test.'

Unlikely as these scenarios may seem, in fact they are already happening. The challenge for mainstream provision is how best to take these lessons on board.

This article looks at three main trends:

- which technologies are coming
- how we are already using them
- what this means for learning.

1

Technology landscape: what is coming?

Mobile learners have a lot of choice. We have many different portable devices competing to fulfil slightly different roles in our lives: news, games, email, music, phone calls, diary, camera…

To understand the trends, we need to look at all mobile devices – including phones, personal digital assistants (PDAs), personal media players (PMPs), portable games consoles and laptops. Our end focus, however, is not the devices themselves, but the mobile learner. What will they have in their pocket and how can we prepare to make the most of it for learning?

Trends

Some technology trends, which have already been well documented, are continuing:

- The power of the processor, memory and battery is increasing and the physical size required is decreasing.
- The costs of many core ingredients are going down (screens, batteries, memory).
- Operating systems, as well as file formats and the media we use for transferring them, are standardising.
- Mobile devices are getting better at communicating with one another in several different ways.

To take the last point, there are multiple aspects to this communication:

- Wireless networks and 3G give us fast data access wherever we are. The standards keep evolving, and future speeds are increasing for both short- and long-distance connections (4G, WiMAX, Wi-Fi, UWB).
- Internet use is no longer restricted to desktop computers. The internet is a living, pervasive web of information available to any device that wants to connect to it (phones, games consoles, satellite navigation systems…).
- The format of the information on the web is increasingly appropriate to many different devices. The BBC site I get on my phone is better suited to a small screen than the same site on my PC.
- GPS (global positioning system) is no longer the domain of specialised exploring equipment. Prices are dropping, and already I can buy a mobile phone that can tell me where I am and where I need to go. This positional awareness opens up huge possibilities for new contextualised and personalised services.
- Bluetooth is connecting all sorts of different devices to one another. This enables us to create our own personalised device by combining the items that are most useful to us. Several other technologies are waiting in the wings to take over or enhance Bluetooth (NFC, WLAN, UWB) but, regardless of which technology survives, the benefits to connectivity will be similar.
- Identification protocols are helping devices to recognise things, and one another, allowing information gathering, personalisation or mobile payment for goods and services (RFID, camera-phone barcodes and so on).
- Standardised connectors let me add features to my devices – USB ports, PCMCIA slots, FireWire, PS/2, SD and CF slots, and memory sticks are increasingly available on many different devices. Today we take it for granted that we can buy a specialised keyboard, an unusual mouse or any printer, and connect it to whichever computer or mobile device we use. End users can customise their own computers more and more to their own needs.

These different trends pull us towards the same place: smaller, faster, cheaper devices working together in a web of connectivity.

Converge or fragment?

But are they converging into a single device? Or will we still carry several different ones? The answer is probably both.

Since the 1970s, Alan Kay and other pioneers of learning technology have had visions of a single device: the Dynabook, a small, portable computer specially designed for creativity and learning. For many years it was only a vision, but at last the technology has caught up. Today I can buy a handheld device with all the power and features of a laptop but one that is not much larger than an iPod. In addition to the specialist players who have already entered the market, several large players like Intel and Microsoft are developing these 'handtop' computers. The price is not quite right, the software is still too business focused and, like many mobile devices on the market at the moment, they may not be robust enough for full-time learning use, but the features make these handtops look a lot like the single device that educators have been waiting for. Furthermore, unlike smaller devices, they can run any Windows-based software.

But this is not the end of the story. A single handheld learning device for every student might well be the tool to help us transform learning, but if we look beyond the classroom, the trends suggest that there may be more than one device in our learners' pockets.

What about their existing communication tools? What about the latest trendy gadget? What about their desire to personalise with snap-on phone covers and ever-changing ring tones? Users seem driven to customise and personalise their surroundings in their quest for individuality, comfort and accessibility. Examples of this are appearing all around us.

Who needs a monitor? I can replace mine with:

- a handheld mini-projector
- a glasses-mounted display
- a flexible, paper-like display (which allows the display to be larger than the device itself)
- a full-face virtual-reality (3D) helmet.

Who needs a mouse? I can replace mine with:

- a joystick or trackball
- a switch (an on/off button favoured by many users with physical disabilities)
- a touch-pen and digitising tablet
- a touch-screen
- eye trackers.

Who needs a keyboard? I can replace mine with:

- a microphone, thanks to voice recognition
- a virtual-reality glove and other haptic devices
- projection keyboards (virtual keyboards that shine onto any surface)
- a touch-screen with handwriting recognition.

Our enthusiasm for using these add-on devices, most of which are already in the shops, is making it increasingly likely that the person you are communicating with, or designing materials for, is using a computer that is significantly different from yours. They have personalised their technology.

OQO Model1+ 'handtop' PC (Source: www.oqo.com)

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Personalisation

How does this relate to mobile trends?

Thanks to the ability to connect technologies without wires, we are seeing the same trends in the PC and mobile worlds. We started searching for the single device that could do everything. We hoped to use it to communicate by voice, text, pictures and video. It would organise our lives, allow us to listen to music, read a book or watch a film. But when we found it, we didn't like it, so we ended up duplicating. I have a camera-phone and a digital camera. I carry both. I can get my email via phone, Blackberry, PocketPC or laptop. I sometimes carry all four! This may be rather extreme, but the reason is simple: it all comes back to us, the users.

Certain interfaces are better for certain tasks than others, and we like to pick and choose what suits us best.

- Screen sizes have gone down and up and will do that again. No matter how small my DVD player, I want a big enough screen to watch the film! No matter how small my digital camera, I want to see the picture at the back. But when I want a tiny phone I am happy to sacrifice video playback to have a small screen. Different optimum sizes are emerging for different tasks.
- Keyboards have also gone smaller and then bigger again. Laptops, phones and PDAs have standardised on an optimum size for their own tasks, but are not successful when doing each other's tasks. For writing an essay, a phone-style keyboard would be tedious, but for making a call or sending an SMS it is perfect.
- User interfaces have also found best fits with different screen sizes. On large screens we are happy to have multiple, overlapping windows, but on small screens we are not, so each application uses a single full-screen window.

Increasingly it is users, rather than technology, that restrict what can be done. Our patterns of use dictate what we want. Users will soon be carrying around a small selection of devices that can communicate with each other, but each will be designed for specific tasks. Just as with PCs, users will personalise their technology by having a selection of devices and functions that best suit their needs.

Three years from now…

Three years from now I expect that I will have the following:

- A tiny 'connectivity tool', possibly hidden in a phone. This will be my high-speed connector to the internet. All other devices I carry that need to communicate will use this. It will connect wirelessly, via 3G, 4G, Wi-Fi, WiMAX or whichever route it can find, switching between them as I move around. This will work for both voice and data.
- Media hub. Think iPod here, but add my digital camera as well as my phone contacts and other personal data. The emphasis of this media hub is all about storage and data, and far less about specific applications. It will record and play back media files, but not much else.
- Communicator (phone). All this requires is a microphone and earpiece. They could be built into spectacles (as several models already are), or in fact any wearable jewellery I want, since the bulk of battery power, controls and connectivity is in the other devices.
- Because I work a lot on the move, I shall probably also have a more advanced reading and writing tool, looking a bit like a laptop with a bigger screen and keyboard for doing more significant work. It will have a decent processor, but will store information on the media hub. When I need to connect to the web, it will use my connectivity tool.

These might not all be separate devices – some may be merged into others. But what is certain is that functionality will be shared between them, and my collection of kit will be different from yours. We will personalise them to make them into what we need. I don't like to watch films on the move, for example, but perhaps you do, so instead of my laptop-type device, you may have a larger, roll-out screen for watching films.

Usage: how we use mobiles

People love gadgets, and are excited by the latest technology, whether digital radio, CD, VHS, iPod or TV. These may seem like (and often are) passing fads, but some developments shift our whole perspective. The success of the web was an example of this, and perhaps the way we use mobile devices will be another. Marc Prensky uses the term 'digital natives' for the young people who are growing up surrounded by technology, and 'digital immigrants' for the rest of us who are still struggling to catch up and learn this new language of technology and connectivity.

Digital natives are able to make huge leaps between technologies and are comfortable finding new uses for them, whereas we digital immigrants need to learn about them in a more cautious, incremental way. If you want a flavour of the future, watch young people: they use their mobile tools for far more than just talking on the phone and checking their diaries. They build communities. They create media. They publish. They perform.

- ***Blogging***
  Users can send a text and picture from their phone direct to a personal website – live and mobile publishing.
- ***SMS to TV***
  Several TV music channels let viewers send a SMS message and it gets scrolled across the bottom of the TV screen to anybody watching.
- ***Podcasting***
  Many mobile devices let you record. Almost as simply as blogging, you can send these audio files to a website and publish them to the world.
- ***Instant messaging and VoIP (Voice over IP)***
  These are the tools of the trade for digital natives communicating for free over the net.
- ***'Connected cocooning'***
  A term coined by an MTV report on the technology habits of young people, this describes how they are permanently plugged into a network of digital devices and, via these, to their virtual communities.

These are powerful forces. The shift from being digital consumers to becoming digital producers and publishers is taking the traditional media producers by surprise.

All of these stories are true:

- During the Iraq war, some of the most accurate reporting was in blogs published by locals living inside the war zones. These provided an insight that traditional reporters were unable to get: look at [http://riverbendblog.blogspot.com].
- During the BBC radio commentary of a football match, while a particularly close call by the referee was being debated, a member of the crowd sent a close-up movie clip of the moment direct to the commentators. Does this undermine the referee?
- Many of the videos shown in news coverage of recent disasters like the tsunami and the London bombings were filmed on the phones of people who happened to be on the spot. The news teams got there too late.
- An African mother living in Europe is trying to teach her home language to her husband and son. She records some practice audio files and publishes them online as a podcast. They have become a surprise hit among dispersed members of the same language group around the world.
- A teacher seems to be picking on student A. Student B films it on her phone and sends it home to mum. She shows it to student A's father, who makes his complaint to the head before the school day has finished.

These examples show how ordinary people are moving from being *consumers* of media to becoming *creators and producers*. The challenge for educators is how to deal with this. Do we ban phones from the classroom because of the concerns raised by flirting, 'happy slapping' or bullying via text and blogs?

Or do we include media studies in our classes to help students evaluate what they see? And do we take the lead from our learners and bring the power of personal publishing into our lessons? It's up to you, but I say **yes**!

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Mobile learning: what is it?

Over the past five years, bands of enthusiastic students, educators and researchers all over the world have been watching the spread of small, mobile devices and exploring how to use these for learning. For some, this is the first real chance to achieve 'one computer, one student'. For others, it is providing educators with powerful new tools. Unnervingly for some, it is a frightening peek into a future where the students are more in control of the technologies than the teachers.

The more we look at the possibilities offered by mobile learning, the clearer it becomes that we are seeing more than just 'the same old thing, but for people on the move'. Several commentators (Sharples, Stead, Traxler) have depicted two distinct aspects of m-learning: 'safe' learning and 'disruptive' learning. These are emotive terms, but the distinction is quite valid.

Both of these aspects have a valuable role to play. The first extends what we are already doing into new places, and the second helps us think differently about learning: learning in a more personalised way, handing over more control to the learners themselves.

- ***Safe learning***

  Safe learning is what people first think of when they discover m-learning. Learners with mobile resources: mobile devices containing learning materials, or even learning for mobile students.

  This can be very effective (as we will discuss later), especially when it gives access to learning contexts that are difficult to represent: the factory floor, a prison, inside hospitals or in places with no electricity.

  It also connects easily with existing materials and processes, but extends them, because time, place and access to computers are no longer barriers. Tools already exist for educators to create their own mobile learning materials, and growing numbers already do so.

- ***Disruptive learning***

  Much of the current debate around m-learning is looking beyond the safe model. Instead of starting from the traditional perspective of how teaching ought to happen, teachers and learners are starting from the other end of the spectrum: "How are mobile devices being used outside education, and how can that be harnessed to enhance my skills?"

  This is a far more personalised approach, as we are talking about *my* devices and *my* skills. It is also more challenging, because control gets passed to the learner. Learners stop being consumers of learning materials, and move on instead to become producers, collaborators, researchers and publishers.

Mobile learning: how well does it work?

Key lessons

Tribal CTAD has been involved in more than twenty trials across the UK, reaching out to several thousand mobile learners. We are collaborating to understand how using mobile tools and approaches can transform learning. Many of our trials have focused not on schools and universities, but on learners who were hard to reach, hard to engage, or hard to access – for example young offenders, Traveller communities, disengaged teenagers and work-based learners in difficult contexts.

Our original definition of mobile learning was broad. In many cases we provided small PDAs. In others we provided resources on learners' own phones. In all cases we were as interested in increasing motivation and engagement as we were in teaching a particular subject.

Across these trials we learned the following lessons about mobile learning.

It works, and it reaches places other learning cannot reach

We know that:

- m-learning can empower and engage
- the engagement and motivation can continue beyond the initial 'gadget honeymoon'
- learners are more comfortable engaging in personal or private subject areas using a mobile device than doing so using traditional methods
- the device can be a powerful tool for self-evaluation and reflection.

A collection of pieces to fit a learning need, not a single solution

When e-learning first became widespread, one of its biggest failings was the assumption that it could become a solution to all learning problems: that teachers were no longer required, and that anything could be 'e-taught'. Success was only about 'broadcasting' good-quality learning materials. We now know that this is wrong, and that good teachers, communication, collaboration and discovery activities are essential.

The good news about m-learning is that it is difficult to make the same mistakes, because the devices being used are much less powerful than PCs. There is clearly no single solution. Screens are smaller. Many have no keyboards. Connection speeds are slower. Processing power is weaker. There is no single 'platform' or set of features that dominates. The learning you can do on an iPod or MP3 player is very different from the learning you can do with SMS. No one can claim that this is the complete solution, as the sales extremists of e-learning tended to do.

In the light of this, it is useful to describe m-learning not as a single entity, but rather as a collection of new tools that tutors can add, combined as required, to their teaching resources. Some of these tools are:

- SMS (text messaging) as a skills check, or for collecting feedback
- audio-based learning (iPods, MP3 players, podcasting)
- Java quizzes to download to colour-screen phones
- specific learning modules on PDAs
- media collection using camera-phones
- online publishing or blogging using SMS, MMS (picture and audio messages), cameras, email and the web
- field trips using GPS and positional tools.

The learning possibilities of these technologies, as well as some of the tools to create your own resources, are explored in much greater depth on the Get Mobile CD-ROM [http://www.getmobile.org] and also on the M-learning website [http://www.m-learning.org].

The challenge for educators is how best to use this new collection of tools, as it implies a stronger emphasis on personalisation than is common practice in current provision. Tutors may now have a wider range of resources at their disposal, but to know how to deploy them well they also need to have a clearer understanding of their learners' needs.

Best as part of a blend

Our many trials tested out a number of approaches to using mobile devices. In some cases the learning supplemented activities already under way; in others the learning activities were constructed entirely around the mobile devices.

In most cases we found that the learning worked best for learners and tutors when it went beyond the mobile device, and incorporated other media or experiences. Typically it was combined with group activities, paper-based materials, other ICT use or everything else tutors would normally do.

These findings are supported by other studies exploring the different approaches to learning and what opportunities wireless and mobile technologies can offer. The JISC innovative practice guide suggests distinguishing between these learning perspectives:

- Learning as acquiring competence
- Learning as achieving understanding (both individually and collaboratively)
- Learning as social practice.

All of these can find a place in our blend.

Not just for teaching, but for creating, collaborating and communicating

Given that our target users have often dropped out of school and may well not have been strong performers there, being able to exploit different learning styles is a key feature of our work. Luckily for us, the very nature of m-learning (as a collection of small pieces) makes it a natural part of the learning mix. Feedback from learners and tutors has been very strongly in favour of this mix of learning models.

When groups of learners already knew each other, they were keen to make use of the collaborative features of the devices: beaming incomplete pictures and messages to each other so they could each add on their own bit and exchanging SMS, MMS and emails. In our research they had often figured out how to do this before we had the chance to show them! Exploiting this as a learning tool provided us with a rich seam of enthusiasm and contribution from the learners.

Some of these activities made use of existing functions and features of the devices for picture taking and drawing, sound recording and writing text. Other activities used external software systems to combine these.

The most useful of these was the mediaBoard [http://www.mboard.co.uk] – an online media store, and web-page creator we developed – to which users can send text and media files directly from a camera-phone or other mobile device.

The mediaBoard was used as a personal diary, a collaborative glossary, an e-portfolio, a group treasure hunt, a competition and a virtual tour guide.

M-learning as a bridge

When working with young people, we assumed they would be skilled users of ICT, but were surprised to find that many socially disadvantaged groups lacked confidence and actively avoided ICT. After our trials, though, several initiated steps back into learning in order to learn about ICT. For them, m-learning was small step towards a massive shift in confidence, autonomy and motivation. This bridge into ICT is a result we also saw in several other trials with different age groups.

The importance of ownership

Mobile devices are not the same as library books. The more you use them, the harder it becomes to give them back and the more they become part of your life resources. Learners who invest the time in learning to use them develop a strong sense of ownership and learning autonomy.

Two innovative school-based projects in the UK gave large numbers of students long-term access to mobile devices, and both groups emphasised the importance of ownership. Students (and parents) need to *own* the devices, and to contribute to their costs and maintenance. Dave Whyley of Wolverhampton LA and John Davies of Dudley LA have both been equipping hundreds of learners with mobile devices and have both come up with a similar formula: that parents will pay the price of a pint of lager and a packet of crisps a week, so that their children can have a mobile learning tool.

Practice makes perfect: just do it!

The final lesson is a softer one. We found that the best way to understand how to fit mobile learning into your teaching is to try it out yourself. There is a bit of technical understanding that tutors need to have before starting, but most of the learning for tutors and students can take place on the job.

In some trials, tutors had intensive training for four or five weeks before learners appeared. In others the tutors started at the same time as their learners. In both scenarios tutors felt that they did not have enough time to prepare, but there was no significant difference in the outcomes, which were all positive. This result suggests that learners are prepared to undertake the learning journey with their tutors, and that m-learning is a powerful tool even when the tutor is only half a step ahead.

Other innovators in the UK and beyond who have been conducting mobile learning trials with more mainstream learners have been finding many similar lessons.

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Summary

Mobile technology is all around us. As devices become cheaper and more interconnected, we are changing the way we use them and integrating them into our personal cocoon of communication, collaboration, entertainment and media creation. The future is more mobile, more connected and more personalised. New generations of learners will expect this as the norm. They will be connected with many different devices, and demand equality, inclusion and always-on access wherever they are.

Models for delivering mobile learning have already started to mature, and the next challenges ahead of us are these.

- Can we adapt our teaching to deal with the challenges of personalisation, always-on access and learner empowerment?
- Will we use these tools to continue what has been started by widening participation and narrowing the infamous digital divide?
- Can we take the lessons of e-learning and m-learning and use these to improve all our other learning?

Let's hope we can all rise to these challenges.

Some resources for educators looking at m-learning

- A lively discussion forum on Handheld Learning [http://www.handheldlearning.co.uk]
- Resources for teachers at M-learning [http://www.m-learning.org] and Get Mobile [http://www.getmobile.org]

Other pioneering projects in the UK

- Mobilearn [http://www.mobilearn.org]
- Learning 2 Go [http://wgfl.wolverhampton.gov.uk/PDASite/index.html]
- CTAD projects [http://www.m-learning.org/projects.shtml]
- Mudlarking in Deptford [http://www.futurelab.org.uk/showcase/mudlarking/mudlarking.htm]
- Savannah [http://www.futurelab.org.uk/showcase/savannah/savannah.htm]

The ambient web

Bill Sharpe

Introduction

We are living through a time of profound change in the landscape of digital technology and the way it interacts with our everyday lives. We are all familiar with the growing range of digital gadgets that have brought computing off the office desktop and into our homes and pockets – digital cameras, smart phones, GPS navigators, music players, personal video recorders and so on. However, these are just one strand of a much bigger generational shift in digital technology that can be likened to the Cambrian explosion of life on earth. At that time, after billions of years of very simple organisms, life reached a tipping point in which there was a massive growth in variety and complexity, giving us everything from social insects to societies of humans. After just fifty years of the computing industry we are also at a tipping point, for we are on the brink of a major shift in the range and complexity of artificial systems that will share our lives.

This shift creates an era of opportunity for education. At the heart of education and learning lie the encounters that an individual has with people, places and things, and the opportunity each encounter presents for interaction, challenge and growth. As digital technology pervades everything around us, we can enrich each encounter to harness the global resources of the information world and of learning communities, to make it more appropriate in that moment to that individual. This article describes the main components of the technology evolution that is under way, and some of the collaborative research between technologists and educational researchers that is revealing its educational potential.

Digital technology in everything

What triggered the explosion of natural organisms and why it took so long is hard to say, but in computing the driver of change is very simple: the amount of computing we can have at a very low cost and in a very small package. We are used to thinking about computing *power* doubling every eighteen months or so, but the more significant shift is that computing *density* can double at the same rate. Invisibly, behind the scenes, computing has been getting embedded into everyday things. Rough calculations of the computing power that has been shipped by the chip makers suggest that the things we call 'computers' represent no more than 1% of the computing that is going on around us. The other 99% is hard at work controlling cars, central heating, doors, kiosks, telecommunications and utility networks and most of the things that we rely on. What is happening now is that the relentless progress in both power and density is combining with the third big factor – *connectivity*.

When the World Wide Web appeared in our lives, it was as if a seed crystal had been dropped into a super-saturated solution. In just a few years a whole new structure came into place, linking up our desktop computers and the world of information into a new level of order. The computers were all there; what was needed was a simple, uniform way to link them. Suddenly everything was possible, as millions of people began to communicate with information servers everywhere. We are now at a similar threshold: the re-organisation of all our 'smart' things as they join the connected world. This will be a qualitative change that is much more than the words 'pervasive computing' or 'ubiquitous computing' suggest, because it will not feel like today's computing any more than driving a modern car with fifty embedded microprocessors does. The technology world uses terms such as 'ambient intelligence' and the 'internet of things', to signal this shift, but 'ambient web' is my preferred term. This focuses on the way that smart things are joining us in an evolutionary web of new capabilities that will become part of the ambience of our lives.

The World Wide Web was built for people to access information. The technical community is now busy building open standards under the headings of Web Services and Semantic Web that will allow the exploding population of smart devices, information services and applications to interact directly with each other over the web in dynamic and flexible ways.

2

Intelligent behaviour of individual things will be achieved through an interaction between the thing itself and the capabilities of the ambient web 'behind the wall'. A simple rule of thumb is that if today a thing relies on power to operate, in the future it is likely to rely on the intelligence of the ambient web.

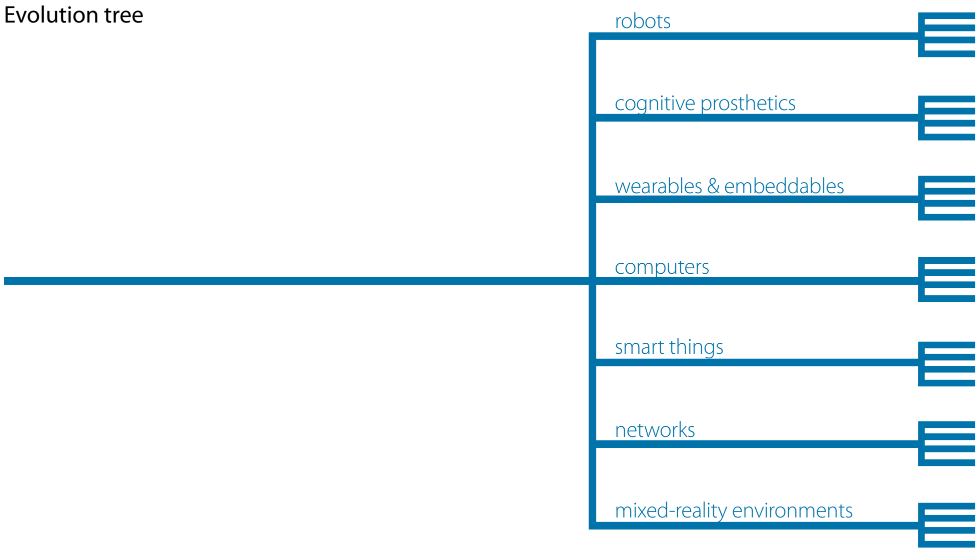
Another major change will be the way that, as individuals, we interface with the online world. We are just seeing computing moving off the desktop and into the smart phones, music players and other small devices that we carry around with us. The cost of computing means that today there is now a forced bundling of all sorts of capabilities into these devices, with phone manufacturers competing to see how many different functions they can get into a small package. This is a passing phase that should give way to what we might call the 'personal digital environment'. This will entail fully connected wearable technology that can be embedded into smart fabrics and whatever form is most convenient in our personal environment – credit cards, jewellery, glasses, coins, wristwatches and so on.

This is a very active research and commercial area in which the fashion and design colleges are involved – for instance, Central St Martins College of Art and Design co-ordinates the UK Smart Textiles[1]. Business, sports, entertainment and healthcare applications are all driving the adoption of these technologies and together will drive into the market a rich set of ways of sensing the personal context and delivering real-time, personalised applications.

You only have to look at people's absorption in their mobile phones and music players to realise that, as the personal digital environment evolves, people are likely to participate even more deeply in online worlds in parallel with the physical world. Children growing up with rich experience of computer games may adopt a range of online persona or 'avatars' to provide interfaces and identities in the online world.
We may see surprising crossovers of media with people using 'artificial' communication in face-to-face situations.

Taken together, these developments will create a profoundly different IT landscape from the one with which we are familiar. It is too soon to know how this period of rapid change will turn out, but the diagram below highlights some of the key areas around which research and development are moving ahead today.

Evolution tree



Networking the ambient web

Computer networking is very confusing – especially the rapidly developing varieties of wireless communication that are key to ambient devices. However, we can think about the main developments broadly in terms of two things that they enable.

First, they enable anything to connect to the internet from wherever it is. 'Anything, anytime, anywhere' has been the mantra of the computing industry for years and describes this goal. This is the main thing you get in your 2.5G or 3G phone, with your Wi-Fi hotspot, and over the next few years with WiMAX. Here the wireless connection is the first or last step in getting you connected to the wired internet and web. Part of the puzzle is letting devices hop between different wireless technologies as they move around – from a hotspot to a cellular connection, for example – and deciding how much you get charged. Another level of complexity involves bringing broadcast media into the mix. By 2010–15 many of these standards may have converged into IP-based 4G networks.

Second, new technologies allow devices to come together and communicate just among themselves. This may be a permanently configured connection, or just a fleeting encounter. Familiar examples are the use of a remote control for the television, and a smart card to pay for a trip on the Tube. The technology of tags (RFID) is set to spread into every sort of device, making it possible for anything to identify what it is and what it can do to the things around it. Bluetooth is another widespread technology intended to create local collections of devices acting together. ZigBee is yet another standard that we will be hearing a lot about in the next few years in our home control systems.

Again, the technical community is extending these ideas to much more sophisticated ideas of self-organising and self-maintaining networks of sensors and tiny devices. In the short term, things will often need a lot more configuring than we would like, but gradually a few key standards should emerge, allowing devices to connect seamlessly and invisibly.

Online learning in the real world

Surviving on the savannah

A research consortium in Bristol[2] has been exploring the possibilities created by overlaying a digital landscape onto the physical world to create 'mediascapes'. Imagine that as you walk around you can tap into sounds, sights and interactions that not only relate to where you are, what you are looking at and what you are doing, but that also augment your experience of the world around you. This is the idea of a mediascape. It works by using GPS or any other location technology, a personal digital environment that can respond to context and play media, and an authoring environment for creating the located content. The mediascape designer maps out areas and events in the environment, and uses movement and action to trigger the media that the user will see and hear.

The Savannah project led by Futurelab[3] explored the use of mediascapes as a tool for learning by allowing children to play at being a pride of lions on a school playing field, which the mediascape transformed into a simulated savannah. The children's personal digital environment included a handheld computer, headphones and GPS sensors through which they could receive sights, sounds and imagined 'smells' of other animals and features in the environment, that together built up an immersive experience as they moved around.

The children were all linked to a common system that meant they were in communication with each other in the simulated world as well as in the normal way in the real world, and what they heard and saw responded to what they did as individuals and together as a team. In addition to the outdoor experience, there was an indoor 'den' equipped with an interactive whiteboard that could represent the simulated savannah; information could be collected in the outdoor world and then reviewed and discussed back in the den.

The main challenge for the 'lions' was how to survive in the savannah. They encountered threats (such as elephants, bush fires and humans) that they had to avoid; they needed to collaborate as a pack when hunting other animals for food; they had cubs to protect, territory to mark and resources such as shade and water to find. They had to balance the costs and returns of various activities such as running, attacking and sleeping, and adapt their behaviour to maintain their energy levels.

The simulation built on real-world knowledge provided by the BBC Natural History Unit, and was made as accurate as possible within the constraints of the technology.

You may already be familiar with the use of games in learning-related research. What is of particular interest here is how rich physical activity could be woven into the interactive experience; sound, sight and movement enabled a complex experience to be built up, creating high levels of enthusiasm and engagement. When running away from an elephant, the children were *really* running, and if they wanted to collaborate they had to move themselves on the playing field, not just move avatars on a screen. Physical movement is enjoyable in itself and the initial results of this and similar projects suggest that this blending of the cognitive challenge with physical experience will be very fruitful.

In fact, the Savannah researchers found that the children could have coped with much harder challenges: a future project could go much further. Looking ahead, we can see many ways in which a future Savannah could go far beyond this first prototype, and how mediascapes can take learning out into the real world. Savannah used the physical world as a blank canvas on which the simulated world was overlaid, but mediascapes can relate directly to where they are implemented, taking social, scientific and environmental learning into the real world. This takes us to another dimension of technology development behind the ambient web – cheap, ubiquitous sensing.

Source: Futurelab Savannah Project

The sensory world

The personal digital environment used by the children in Savannah – handheld PC with headphones and GPS – provided very little information to adapt the experience to what was going on in the environment and what the child was doing. Wearable sensors could be used in a wide variety of ways to enrich the experience. The simple addition of a digital compass can bring a much tighter level of integration between the mediascape and the physical world, because the sights and sounds can be directly aligned with the way you are looking. This has already been trialled in the Mobile Bristol project, providing panoramic views on the handheld device that match the physical view. Imagine walking around a historic site: you could look at the ruins of a castle and then see the building as it would once have been. How much better than reading about it on a static signboard! Direct delivery in this way can also adapt the information to the needs of the particular user.

Sounds, too, can be significantly enhanced by using a compass with GPS to create true 'situated sound'. This is more than just stereophonic sound, which creates a soundscape in your head, unconnected from the real world. Situated sounds are placed in the environment, and will appear to come from that place wherever you move, so it is possible to make the bells ring out from the ruined bell-tower, or to make people and animals move around the landscape. Experiments have shown that sound is a powerful way of creating experience, and the effects of situated sound can be highly dramatic.

Another way to use sensing technology is to enhance the senses. Why not hear like a bat, see like a hawk or smell the world with the sensitivity of a dog? Imagine being able to go out to the woods in the morning and 'smell' the trails left by the night animals, experience the world through their senses, face their challenges, and become a participant in their very real 'game' of survival. All these possibilities will soon be realised. Sensing technology is advancing rapidly as part of wearable computing, so it will be possible to use all these sources of information to create mediascapes.

Sensing of the environment will take on a new level of meaning as vast arrays of simple sensors that can be scattered around and create a smart sensing 'mesh' become available. Many research teams are working on approaches to tiny sensors that can be spread through the environment and will create *ad hoc* networks to pass information from one to another until it reaches a collection node for transmission back to base – see Envisense[4], for example. This means they need very little power and can perhaps even just be solar powered. In this way the real world can be linked to the mediascape. A child studying pollution, for example, might be given an interactive map of the city, showing current pollution levels. She could go and 'look' at the map by walking around hot spots with her 'chemical senses' turned on, and take photos of emission sources. Back in the classroom, all these resources could be shared and discussed.

The Savannah experience was limited to a single day for each group of children, but of course the materials and experience of the game could be built up over time, in line with the development of 'perpetual' games. The same technology that delivers mediascapes can be used to leave information in the environment that can accumulate. In this way the ambient web will create an ever-growing density of information in every physical place. This is part of the next big trend that will have profound effects for education – people as participants in building the web, not just recipients of published information.

2

Social learning

Podcast, blog, Flickr, wiki… a growing lexicon reflects the arrival of a web that is built by all of us in a torrent of sharing and do-it-yourself activity. Each wave of pervasive digital technology drives a significant advance in our ability to create and communicate media, as well as to consume it: the first generation brought us desktop publishing and email; we are now well into the second generation enabled by the web; and we are beginning to research the impact of the third – the ambient web.

What we see in the current generation of the web is that people are finding an ever-growing repertoire of ways to connect conversations together as shared media. At one end there are very structured examples such as Wikipedia, the free encyclopaedia. At the other end of the spectrum are sites such as Flikr[5], where people post photos and create all sorts of strange collections of them by assigning them descriptive tags. In between there is every sort of variation between formality and informality of content, and personal and shared control, as people explore ways to express themselves and share their interests.

The ambient web extends this by placing all these capabilities in the context of located media. This will transform the way we perceive public space, as it will allow us to create shared meaning by using the web directly connected to day-to-day activities out in the world. The societal potential for this has been explored recently by projects such as Urban Tapestries[6] and Presence[7], which showed there is an enthusiasm for located, context-sensitive media that is at least as strong as for the conventional web. Two recent projects – New Sense of Place and Mudlarking in Deptford – have explored the learning potential of involving children as active participants in building interactive mediascapes.

The New Sense of Place project[8] explored how children could use mediascapes to enhance their geography studies in urban settings. Over a period of several weeks the children created soundscapes (located sounds only, no pictures) that all related to a particular piece of open space close to their school. They were free to decide what sort of content they wanted and to control who it was shared with.

The children responded with enthusiasm and their soundscapes were as varied as titles such as 'Evil Footsteps', and 'Secret Super Wood' suggest. When invited to think about how they would extend these ideas into their local neighbourhood, they easily generated a wide variety of both playful and serious uses.

The other recent project, Mudlarking in Deptford, a collaboration between Futurelab and Goldsmiths College[9], took children's participation in creating mediascapes a stage further. The core idea was to take the concept of a guided tour and to give the students an active role in producing and evolving the content over time, directly through their involvement in the tour. The content was all concerned with its particular location, Deptford Creek, and included relics, natural features, community stories, imaginative visions and any other way that meaning could be built around the specifics of the place. The project paid close attention to the tools that enabled the children to capture data, construct stories and 'place' the content in the environment where other students would access it.

Mudlarking in Deptford. Source: Futurelab

Insights are still being gained from these experiments, but two themes have already emerged. Firstly, situated physical learning is a powerful means of enhancing student involvement and engaging students in the learning process in rewarding and enjoyable ways. Secondly, the role of teachers and the role of peers may change. The Savannah researchers comment on the learning approach that surrounds gaming experiences as being 'just-in-time learning, trial and error, and participation in activities with more knowledgeable others'. In the Savannah project they made what they now regard as the mistake of requiring the children in the den to act 'as pupils' and listen to information. They report, 'What has become clear is that the use of game formats is unlikely to sit easily alongside traditional classroom power relations. Gamers are expert when they control their own learning alongside more knowledgeable peers'. As they say, it may take a certain courage to follow through the implications of this observation.

These projects also raise interesting possibilities for enriching the resources brought to bear in the learning experience by embedding them in a network of communication with peers and other people who can be engaged with their experience. The Mudlarking project specifically encouraged ways for the children to communicate with each other around the construction of the tour, and found that this collaborative building was a very powerful process for them. In the project the teacher could provide expertise on location, but all other expertise had to be 'pre-loaded' in content that had been acquired beforehand.

It is interesting to speculate on how this could be extended by allowing many more people to participate remotely in the children's learning by being 'alongside' them in the online world. These people could be teachers, experts or any community members who could enrich the experience, just as a guided tour can involve a variety of people. The web is already allowing people to be threaded into many evolving conversations, and this could be extended into participating in the children's interactive explorations.

Perhaps in the future a museum will be a sort of control room for a variety of tours in the neighbourhood from which people could be connected to a wide variety of on-location experiences. A geology expert could 'drop in' on a child's tour and look at the same feature as they are seeing and answer their question in the moment. Or a community member who had provided a particular story might come on line for some conversation. Museums and libraries are likely to think of their job as becoming an active, and interactive, curator of their wider physical setting rather than just a concern with what is inside the walls.

2

Learning intensity

All the experiments we have reported – and there are many others – point to the possibilities of deepening children's engagement because they are involved more, and can be challenged more, in ways that they enjoy. The overall effect of the ambient web on learning can be thought of as the opportunity to enhance learning intensity through a wide variety of means: more immersive physical experience; richer interaction with the environment; personalised content; real-time collaboration with co-learners; and participation in building content.

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The future of human-computer interaction

Paul Anderson

Machines that fit the human environment instead of forcing humans to enter theirs will make computing as refreshing as a walk in the woods.

Mark Weiser, 1991, The Computer of the 21st Century

PCs, we have a problem!

Education is changing, engaging in newer styles of learning that are blended, more personalised and have an emphasis on activity, collaboration and exploration. Increasingly, teachers want some of this to take place beyond the walls of the classroom so that learning becomes more embedded in everyday activities. It is clear that ICT can help to achieve these objectives: computers are now central to education and their use is seen as a powerful catalyst to educational change (Becta, 2005). However, most computers in schools come in the form of the PC – familiar rows of desktop-bound boxes and screens – and this presents a number of problems.

Firstly, growing numbers of computer designers and educationalists believe that the PC presents several barriers to use, since as a device it lacks flexibility, and is overly complex and difficult to use: people spend more time learning about the computer than using it (Shneiderman 2000; Norman 1999). Secondly, computing as a discipline is in the middle of a paradigm shift. The second wave of computing, which focused on providing an individual with a single multi-purpose computer, is being supplanted by a *third wave*, which involves the fragmentation of computing power over many media-rich networked devices, gadgets and systems. In this third wave, the *ubiquitous computer* ('ubicomp') offers us computing power that is constantly available and embedded all around us.

This means that just as education is beginning to reach the second-wave goal of providing a 1:1 PC–pupil ratio, this paradigm shift is rendering the PC out of date. Increasingly what is offered in the classroom bears little resemblance to the flexible, mobile and to a certain extent more 'friendly' technologies afforded by the digital lifestyle outside the school gates (Leadbeater, 2005). Although there are some good examples of the use of innovative digital technology and practice – such as the Islington City Learning Centre (Dodson 2005), the Savannah project (for a summary, see Naismith *et al*, 2005), the Design Council's 360-degree flexible classroom project and, in the US, the Stanford iRoom project (Figure 1) – it remains far from mainstream.

In order to deliver the educational vision, therefore, computers need to be more usable, friendly, flexible and mobile. And as technology blends into the environment around us, our relationship to the technology – the way we interact with it – will be of fundamental importance.

This 'bridge' into technology is known as human-computer interaction (HCI), and third-wave-related developments in HCI will profoundly influence how we interact with machines. This article reviews some of those developments and, in three possible scenarios, explores the potential for changing education.

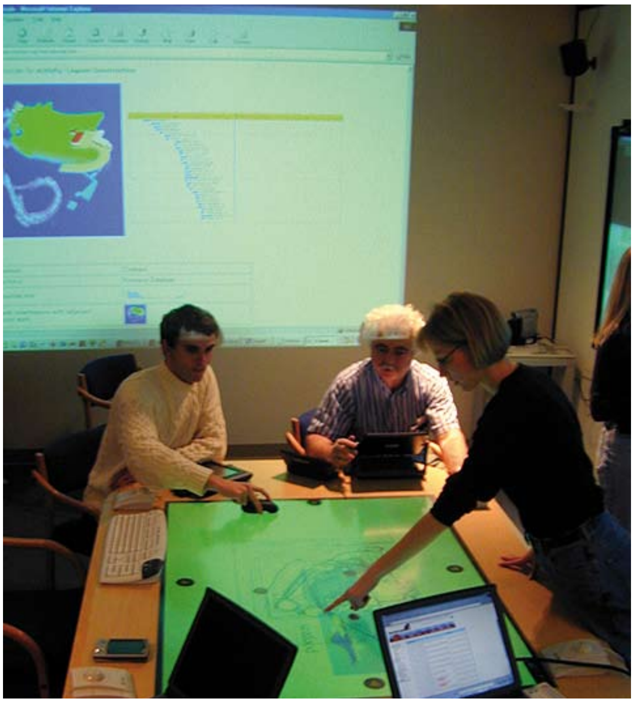

Figure 1: New classroom design can facilitate interaction: the display table at the Stanford iRoom project (Source: Stanford Computer Science)

3

Trends in HCI and usable machines

The way we interact with computers is changing rapidly. As we shall see from the scenarios outlined later on, there are exciting innovations taking place, with the emergence of new technologies such as electronic paper, 3D display screens, tangible interfaces and near-to-eye display systems. However, these technologies are not developing in isolation: they are being introduced within a changing context of trends and patterns in interface design and usability. In order to appreciate more fully the potential for these technologies to change education, it is important to understand these trends and they are summarised in the following table.

Recent trends in HCI development

Trend	Explanation
Usability and universal access	General increase in awareness of issues of usability and diverse usage of computers
Natural interaction and multi-modal	Interaction with computers that is more natural, anthropocentric and multi-modal (ie making use of all five senses)
Implicit vs explicit	Increased use of implicit interaction, indirectly, while the user is doing other things
Adaptive and perceptual	The interface's awareness of the context of the interaction, for example the emotional state of the user
Credibility	Is the machine telling the truth?

Usability and universal access

Led by design radicals such as Shneiderman, Nielsen and Raskin, there has recently been a new focus on the user rather than the device itself and on working to empower him or her to undertake tasks 'seamlessly'. The aim is to wrap the computer round the human rather than the other way around. As part of this work, there has been a movement towards *universal access* (Shneiderman 2000) – the recognition that users are diverse and have varying abilities, and that 'one size fits all' design does not work.

Natural and multi-modal interaction

In the future we will interact with computers in more natural, human-like and richer ways: in short, in a more 'friendly' manner (Horizon 2005). Research shows that we tend to treat computers much as we treat fellow humans and that we want to communicate in a way that supports our natural communication modalities by, for example, making use of facial expressions, body posture, gesture, gaze direction and voice. Currently our communication with machines is highly visual but, as we have five senses, more use could be made of touch, sound, and even smell. We are – in the jargon – *multi-modal* and, as such, we quite naturally process information by using different 'channels' simultaneously. In education, multi-modal communication is seen as particularly beneficial for supporting children with special needs.

Implicit vs explicit interaction

Traditional interaction with computers is explicit – we usually go to a computer, sit down, and start typing and viewing information on the screen. In contrast, implicit communication takes place incidentally, while the user is undertaking another task, without the need for specific, direct communication. This trend is strongly related to multi-modal interaction and the driver for this development is mainly coming from the ubiquitous computing movement, which suggests that 'the interface itself can take on the responsibility of locating and serving the user' (Dix 2004, p717).

Adaptive and perceptual interfaces

Device interfaces will become *perceptual* in their interactions with users and the environment, and will increasingly be equipped with vision systems, movement sensors and pressure pads incorporated in the mouse and classroom seating. Mobile devices enabled with GPS will make far more use of geographical position data to provide location-based services. Driven by this heightened technical 'awareness', human-computer interaction will become increasingly *adaptive*, with more responsiveness to the context in which the communication is taking place. These adaptive and perceptual interfaces will also be able to take account of the mood – the psychological and emotional state – of the user (*affect perception*). Such perception is viewed as particularly important for the long-term development of learning systems, since the affect state of a person is a key determinant in their learning capabilities, creative state and thought processes (Picard *et al* 2004).

Credibility

Finally, we can begin to consider the credibility of a computer and its interface and communication patterns. As digital devices become more ubiquitous and widespread in our educational environments, and as they communicate in a more human-like manner, questions about whether or not they are telling us 'the truth' and feeding back accurate information will become increasingly pertinent and more difficult to address. Computing technology will become 'too diverse for a single answer' (Fogg 2003, p141). Interestingly, as computing becomes more complex and diverse, with more human-like systems of communication, the long-term question may arise, much as it has in human communication: has the system generated a credible answer, or has the communication itself created a problem?

HCI in schools in the future – three scenarios

To illustrate the impact these new trends and technologies in HCI may have on the future of teaching and learning, we present three educational scenarios: imagined visions of the future based on projections of current and emerging technology. Following each scenario there is a short explanation and discussion of the technologies involved.

3

Scenario 1

Imagine...

In a typical classroom in five or so years' time a group of children are gathered along one wall, waiting to begin a history lesson. The teacher enters the classroom, approaches the front and stands still. In response to her entry, the classroom's ambient lighting dims slightly. She moves her hand in a waving gesture and begins to talk about the life of a soldier in Julius Caesar's army. The wall along which the students are standing, which is actually a computer display, comes to life, showing across its entire length illustrations and high-definition video in time with the points the teacher is discussing. A range of subtle odours is released into the classroom air by the display to heighten the awareness of the period.

Later in the lesson the children are asked to role-play as soldiers, in small groups, at the display wall. The display wall splits its images into a number of small windows with each one showing an animated 3D image of a Roman commander. The children verbally interact with the commander, discussing tactics for the next day's battle. The commander can respond to a limited range of spoken questions and, in the process, shows them animated maps of the battle plans. The children interact with the maps, using their fingers to point and move items around the screen.

This scenario introduces four emerging technological developments in HCI: the wall-sized display screen, 3D displays, speech input and the potential for the use of smell.

The wall-sized display is one of a number of potential display developments facilitated by changes in the underlying technology of display screens (Figure 2). In the last few years we have seen a move away from the bulky cathode-ray TV screens (CRT) towards flatter technologies based on liquid-crystal displays (LCDs) and plasma. Although LCD and plasma screens are continually increasing in size, they are not yet able to provide the kind of wall-sized displays referred to in the scenario. However, in the next few years a new generation of flat-screen technologies will come on stream, based on novel physical mechanisms for illumination (Anderson 2005).

At the moment, the two leading contenders are organic light-emitting diodes (OLEDs) and polymer light-emitting diodes (PLEDs). OLEDs use a very thin film of an organic substance that can emit red, green, blue or white light when a charge is applied in a process called electrophosphorescence.

PLEDs use a similar mechanism, replacing the organic layer with a polymer. Both technologies are self-luminescent (and therefore do not require a backlight) which means they use low levels of power. They also offer very high levels of picture resolution and quality and, most importantly, can be manufactured to be so thin that they can be sprayed on to large flexible sheets (in a process resembling ink-jet printing) to create display surfaces. Such materials are predicted to be incorporated into new flexible displays moulded to the contours of mobile phones, car dashboards and furniture. Additionally, they could be rolled up for use as large, portable, public display screens, or attached to handheld devices (to overcome the inconvenience of viewing media-rich content on small screens).

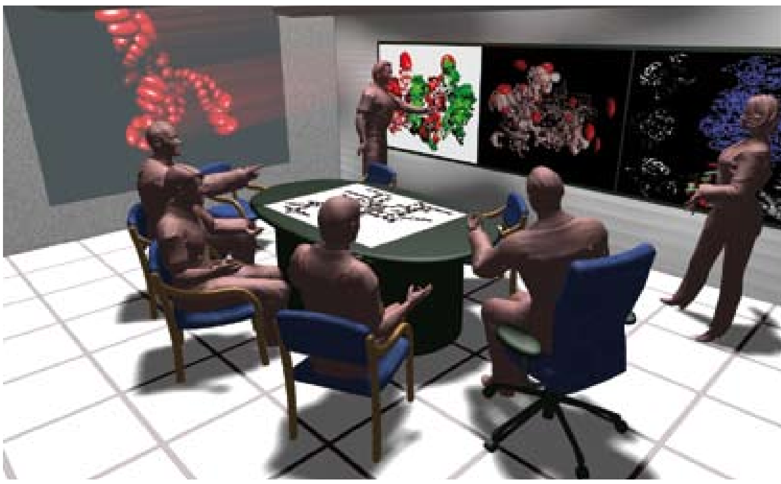

Figure 2: Wall-sized displays can facilitate classroom interaction: the Stanford iRoom project (Source: Stanford Computer Science)

The children in the history lesson were viewing 3D images. Despite its futuristic-sounding nature, the technology to deliver a 3D image on a desktop computer or TV is developing extremely rapidly, with a number of high-end commercial products (aimed at visualisation in 'big science' and medical research communities) already in production. These technologies basically work by exploiting the inherent human stereoscopic viewing system; in other words, we see in three dimensions (partly) because each eye sees a slightly different image from the other and this provides our brain with visual depth 'clues'. Three-dimensional displays replicate this by using clever optics on the front of the screen to send differing images to each eye. This effect is achieved by using a monitor which scans the iris to track the position of each eye (as the viewer's head moves about) in order to keep the optics aligned precisely (an example of adaptive interfaces).

The history lesson also involved the use of speech between the children and the animated commander. For many years it has been one of the dreams of computer science to facilitate natural conversation between computers and humans. There are three advantages to using speech as an input/output mechanism. The foremost is that speech is an ambient rather than an attentional medium: we can talk while doing something else. Secondly, speech requires only modest technical resources – a speaker and a microphone – although the computational requirements can be phenomenal. And finally, speech is descriptive rather than referential, so speech and the use of pointing and gesture can be complementary in multi-modal scenarios (Rosenfeld *et al* 2001). Although much progress has been made in recent years, natural free-flowing human conversation remains some way off. This is a difficult problem to crack and we do not yet have systems that are comparable with human communication – existing solutions are at least an order of magnitude worse than that of human listeners. This is not to say that progress is not being made, and systems that recognise individual words in limited domains can get up to 98% reliability with vocabularies of 100 to 10,000 words (Kirriemuir 2003). Such systems have been very successful for students who have disabilities that preclude them from using the keyboard.

The scenario also made use of smell to help evoke the historical place and aid the students in their imagination. Smell can be powerfully evocative and has been used with some success in museums (for example, the Jorvik Viking Centre in York) and was briefly experimented with in the 1950s film industry (when there were experiments in, yes, Smell-O-Vision!). Despite this, the use of scent and aroma in human-computer interaction has been little used and is regarded by interface experts as a fairly unexplored medium. Technically, developing smell-based systems is problematic since the human nose can detect odours based on at least 1,000 molecular bonds and this makes it extremely difficult to categorise and make odours from a few basic primaries (although, by contrast, we need only red, green and blue primaries for a colour TV picture). Despite this, some limited work has been undertaken in recent years on smell-based HCI from research labs such as MIT (the inStink project) and companies such as TriSenx.

Figure 3: Child using headset to view augmented reality demonstration of airflow over a model aeroplane wing. (Source: European Connect IST project)

3

Scenario 2

Imagine...

Across the school a teacher is leading a science class. Each student wears a pair of special glasses that project images directly into their eyes. The students hold various plastic models of chemical molecules and are asked to interact with other students holding different molecules. As the students move around the classroom, bringing their own molecule into contact with another student's, the glasses display information, overlaid on the child's view of the molecular model, about the bonding attraction/repulsion forces for the chemicals involved. Various auditory noises and cues emanate from the molecular models as they are moved around and pushed together.

The teacher directs from the sidelines as the students are asked to learn about each other's molecules and work together to build appropriate proteins. As they move around, they take notes on pads of electronic paper before returning to their desks, which have screen displays embedded into them.

The children in the chemistry class scenario are using two key emerging HCI technologies: *tangible user interfaces* and *near-to-eye display* systems. Tangible user interfaces (TUIs) employ the direct manipulation of physical objects as the intermediary between the human and the computer. These objects may be everyday objects, physical models or 'artefacts' which are touched, moved, grasped and manipulated as part of a tangible interaction with the computer system. Examples of the kind of artefacts used in TUIs in school experiments to date include toy bricks (such as Lego™), pieces of special string, 'magic' paintbrushes and coloured balls. These artefacts provide a gateway to the digital systems or space, allowing a blending of the real and the virtual in a process sometimes known as *mixed reality*. The long-term vision is to blend the digital world with everyday objects, helping the computer and its interface to disappear, and making the digital information world tangible.

In recent years TUIs have undergone considerable exploration in school environments, particularly with younger children, and a report for Nesta by O'Malley and Stanton-Fraser (2005) reviews in detail these research findings. The research suggests, with some caveats, that there are real learning benefits from using tangible interfaces and it is widely believed that physical movement and gesture support children's learning processes.

In the chemistry class, the children are viewing additional information that is being projected into their eyes using special glasses – a technique known as *scanned beam*, a form of near-to-eye display. The glasses contain a micro-display system which scans light from lasers or PLEDs directly onto the retina while also allowing the viewer to continue to see the real world.

Current near-to-eye prototypes are still somewhat bulky but in a few years' time it is likely that the screen technology will be miniaturised and the devices will be indistinguishable from a pair of spectacles or sunglasses. As the children can see the real world at the same time as they receive additional visual information through the glasses, they are experiencing what is known as an *augmented reality*.
Such augmentation is being used in experiments in education already, either indirectly through the use of handheld display devices and audio headphones (for instance the Savannah project, see Naismith *et al* 2005) or directly through head visors (Figure 3).

Finally, the children are taking notes on electronic paper, a novel display technology which differs from those outlined in scenario 1.

Electronic paper provides a highly readable display format, similar to conventional paper, which can be written on using a pen that delivers electronic 'ink'. These displays differ from conventional 'rollable' flat screens in that the electronic ink remains in place even when the power has been switched off, and can remain on the screen for months or even years without electricity. The development of such paper, together with the uptake of tablet and handheld devices, will increase the amount of pen-based handwriting input to computer systems.

Scenario 3

Imagine...

John is learning about Shakespeare by acting in a play. On the school stage he is engaging with a computer system to help him learn the role of his character and explore the meaning of the play through the delivery of lines and the rhythm of the language. A large display projection shows him examples of famous actors undertaking a scene from the play and the computer prompts him to carry out his part in turn. Dialogue appears on the screen, and as John acts out the scene the system senses his movements, gestures and emotional state, providing relevant directions through a wireless earpiece.

The display projection appears at appropriate points around the stage as required so that he can always see a projected screen as he moves about. John also engages in sword-play work with an artificial sword and a tactile system attached to his arm, which feeds back resistance when it is hit by an imaginary adversary's sword.

While this scenario takes some liberties with what we can expect with regard to the artificial intelligence capabilities of computers, it does illustrate the forthcoming rise of more perceptual interfaces. Human communication is subtle and uses a combination of gesture, facial expression, speech and body language. Although this is difficult to achieve in practice, interfaces will become far more aware of all these aspects of human communication through a combination of sensing technologies (Pentland 2000). The ability to make greater use of gesture is seen as particularly important in educational situations and, as an example, technologies that can track eye gaze have become important for helping to improve access to technology for those who have disabilities.

In a similar vein, researchers are looking at the perception of emotions and the role these can play in human-computer interaction (Marcus 2003). Interfaces based on these techniques will make interpretations of the emotional or affect state of the user and will respond to non-verbal cues by sensing a range of physiological inputs. MIT's Galvactivator is a glove that senses the wearer's skin conductivity (a potential clue to the user's psychological state) and is an early example of this kind of technology. The educational potential of such affect-perception systems is beginning to be explored with a view to developing a machine that is more able to help a learner, acting as a 'friendly' motivational tool with a 'psychological' presence (Picard *et al* 2004).

Interfaces could, for example, detect and respond when a young child is losing interest, starting to fidget, and therefore perhaps failing to understand the learning material.

The scenario also illustrates the use of haptic interfaces. These increase the sense of realism of interacting with a system by incorporating a level of physical feedback as they are used (offering resistance when moved or pushed, for instance), as the sword play illustrates. In the same vein, touch-screen displays which incorporate the 'feel' of a physical button have recently been announced.

Finally, in the scenario above, the projected display that John was viewing moved with him as he acted out the scenes. Such systems, which track the location of the user in order to position a projection on a wall or surface, are already being researched and developed. A leading example is the work being undertaken at IBM in the Everywhere Displays project (Pingali *et al* 2002). In the longer term there are also plans to create interfaces that are animated, and that seem to respond sympathetically to the user by shifting position in mutually reciprocal ways as the human uses the system (Picard *et al* 2004).

3

Conclusion

In recent years, education has focused on increasing the use of ICT in schools through the introduction of basic technologies: PCs, laptops, interactive whiteboards and projectors. While these technologies are beneficial and have been shown to help with educational tasks, their design and usability are an issue, and they represent a barrier to our relationship with technology. This article has argued that changes in the technology surrounding the human-computer interface will change the manner in which we interact with machines in educational settings as new developments in display, speech, gesture and tactile systems are introduced.

These developments should not, however, be seen in isolation, and HCI is part of a wider debate on human factors and the design of our workplaces and educational establishments. The Building Schools for the Future (BSF) programme is helping to focus minds on the actual design of learning spaces and their supporting technologies. Educationalists are beginning to exploit computer systems in workspaces and classrooms which are designed to facilitate high levels of interaction and shared working. These projects point to learning environments that forge a new relationship between learners and technology.

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Social networks

Leon Cych

Introduction

In the last two years the innovation made possible by pioneers of the internet in the early to late 1990s has begun to mature and evolve. Because of easier access to broadband networks, some people and systems have started to focus on, coalesce around and – most importantly – build exciting digital technologies and services never available before. From these new, social ways of working, practices are emerging that have cultural, philosophical and educational repercussions.

There is growing opportunity for frequent and more reliable connectivity; all over the world specialist social networks and collaborative working groups are forming. All are driven by, and have in common, the fact that they are making intensive use of a collection of emerging technologies to communicate and evolve communities of ideas in virtual spaces that are helping to radically change working practices.

In many parts of the world this activity has been a 'ground-up' phenomenon and has been recognised and driven by the commercial and open source software communities. Both of these sectors have evolved new technical infrastructures and what appears to be happening is that people are building these systems almost on the fly. The speed of development is getting faster – with monthly, weekly or even hourly rapid prototyping taking place. Blogs, wikis, moblogs, vlogs, folksonomies and podcasting are all recent examples of these new ways of communicating that are built on and exploiting these systems. They are all part of what has become known as Web 2.0.

Web 2.0

About a year ago, two key observers of this phenomenon described aspects of Web 2.0. Chris Anderson[10] published an article in Wired Magazine outlining the Long Tail of business. This referred to the fact that online companies were now capable of using the web to sell a vast range of products from 'mainstream' popular items right down to the singularity of one unique unit. This has led to greater productivity and sales – for example towards the end of 2005 the iTunes online music store sold more music in the US than some of that country's biggest traditional retailers.

Google, Ebay and Amazon are all successful Long Tail businesses: the reasons they flourish financially are, in the main, the rise and spread of computer networks and the ease with which the more affluent are increasingly using and exploiting them for consumer choice. However, one of the main strengths behind these businesses is that they are able to aggregate customers' opinions, and then analyse and feed them back into the sales cycle with very precise marketing – their power lies in providing a mechanism for differentiating to a spectrum of different customers' needs and wants, and then using these to make further sales.

Around the same time the academic internet book publisher Tim O'Reilly[11] released his meme map[12] diagram describing some of the elements of Web 2.0. Tim O'Reilly's diagram can be used to outline and map some main equivalents in education. The underlying mechanics of joining information up in newer, faster and more efficient ways that anyone can control in a commutative way is one of the keys to greater productivity, and results in a greater engagement on the part of the consumer or learner.

It is akin to what Stephen Heppell calls *symmetry*[13]. The learners in his studies were keen to have far more control over their information and data; they were producers as much as consumers and, when presented with the opportunity to participate, found the process far more compelling because of this. He says, "This is closer to a model of communication than a model of dissemination and it is the future."

What are the implications for similar activities, collaborations and new institutions and structures in education in the future?

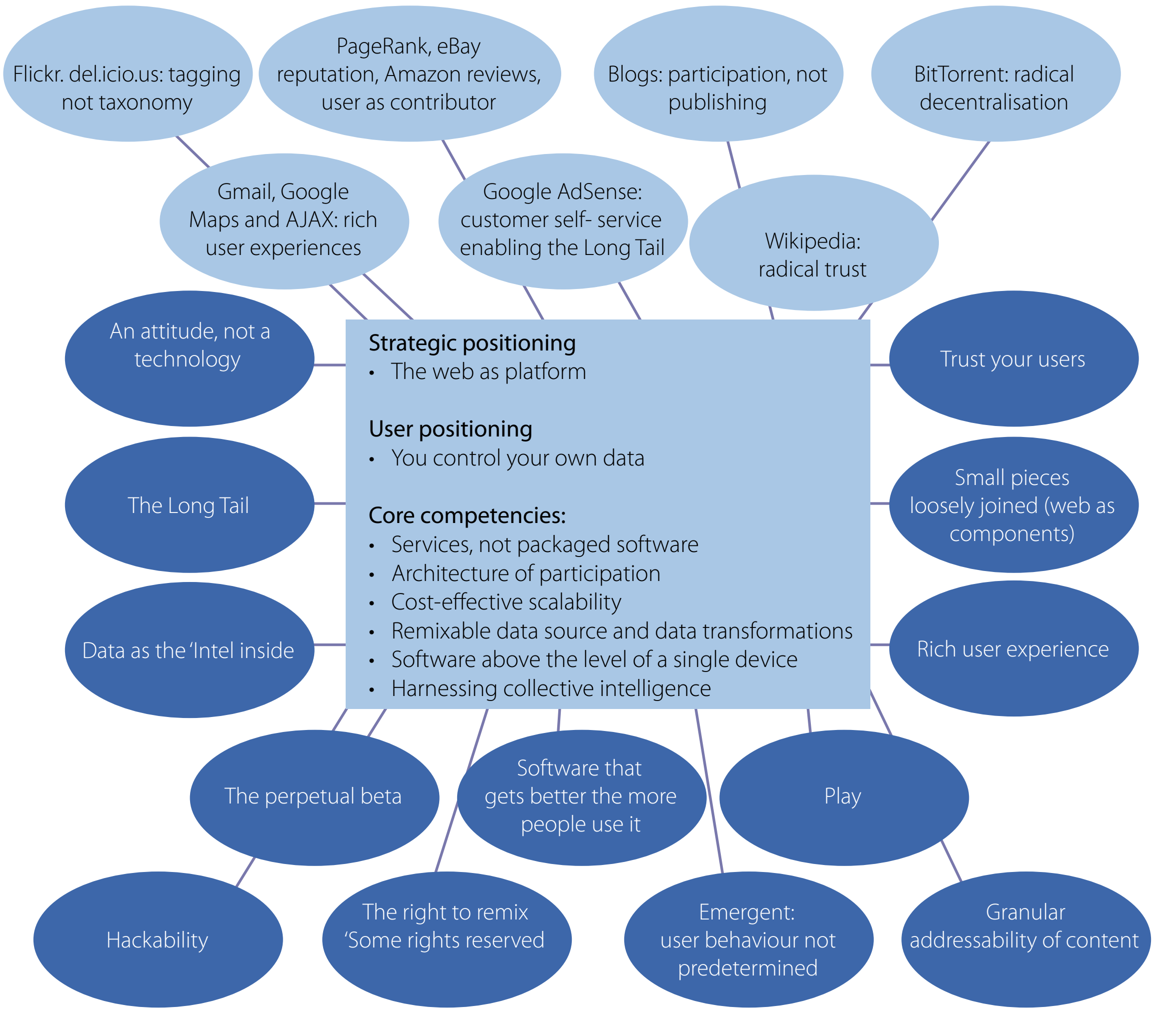
Here are some possible parallels in education:

- Customers – learners
- Product – knowledge and skills
- Web services – educational services/pedagogy
- Personalisation and choice – differentiation/personalised learning.

These services through collaboration and innovation appear to be enabling a form of collective intelligence[14], which many educational practitioners are exploiting to make new models of teaching and learning.

4

Web 2.0 Meme Map



Source Tim O'Reilly

Web 2.0 technologies adapted for education

Flickr is one example of a website that uses these new technologies – it allows users to upload photographs and then collectively add comments to them; it also allows students or teachers to tag photos with data in the form of keywords. In one early example a teacher used these comments boxes as a mechanism to get her students to write about the detail in an uploaded photo-reproduction of the Merode Altarpiece by Campin[15].

This makes a very precise and informative *collective* resource. In fact, all the students could add weblogs that could then be linked into the resource and they could, in turn, tag their portfolios or comments with reference to the online discussion. Obviously copyright and net security are issues here, but this is one early exemplar of how educators are using the technology to facilitate constructivist learning activities. Some elementary schools in the US are beginning to use this technology in the public domain[16], but in the UK use at this level of institution is still bounded by several issues surrounding IPR and personal safety[17].

Flickr makes use of the concept of folksonomies, which are underpinned by tagging technology; these sites are becoming more commonplace on the web. Social bookmarking sites such as del.icio.us work in very specific ways. They encourage groups of users to mark web pages with a specific tag or tags – each individual user tags a website they have found useful with a simple description and some key words. People can then search using these user-generated key words or phrases for specific content. Some tags are generated again and again, so that it is possible to see trends of interest and research. Tagging is also now generally used on photo, video, document and archival sites as a search tool. Whereas the trend before was to write and generate machine-readable metadata to trace specific information, folksonomies seem to be a quick, efficient and highly contextual way of finding specific human-generated content. Again, user interest often coalesces around trends or cultural themes to create an online cultural virtual space not definable in any other medium. Tags are proving to be extremely efficient search and collaboration tools in this respect. Yahoo has now bought both Flickr and del.icio.us.

Google Maps, Geo Tagging and Google Earth

Google Maps[18] is another example of a web service that has been adapted for social networking. It was a resource that passed into the educational community fairly quickly – again it is free with a more detailed and professional version available commercially. You can zoom into any area on the globe and overlay or tag information onto any of the maps.

An allied resource is the Geobloggers[19] site. This uses the Google Maps API[20] combining three website resources – the RSS feeds coming from Flickr, Google Maps, Google Earth – and other allied web technologies[21]. You can take a picture of a location anywhere on the planet – look it up on Google Maps and tag the latitude and longitude into Flickr and create a link from that picture to Google Earth[22], which is a highly dynamic online atlas. Having done this, you can fly in an animation to your online tagged photo onto the surface of the planet where it is located. The social interaction and rich information systems resulting from such a resource are obvious in certain curricular areas.

Open APIs

Application programming interfaces (APIs) enable users to add functionality to existing services or use the data from websites as part of other services. Many web companies are now making access to APIs freely available (open APIs).The best developments may even be incorporated into the original service for others to use.

4

Collaborative tools

Two prominent collaborative tools being used in education are wikis[23] and blogs.

Wikis

The word wiki is a Hawaiian term for hurry[24]. Wikis are websites that allow users to add, edit and delete content; it is usually a joint collaboration on the part of several authors. One well known example, Wikipedia, is an online encyclopaedia that anyone who has registered can contribute to. However, many of the contributors are also moderators: unfinished or part-articles are called 'stubs' and need to be moderated, worked up and polished before they are accepted into the main body of the work. A wiki web environment differs from traditional online learning in that it encourages both teacher and student to learn together: knowledge is no longer transmitted from one to the other, but each person shares a part of what they know to construct a whole – in effect another form of peer-to-peer constructivist learning.

Some wiki users may post ill-informed, badly researched or downright abusive information or may intentionally delete parts of the wiki. Most wikis are self-moderated and any breaches of etiquette quickly pointed out and amended or discussed. Most wiki pages used to be completely open to the world and could be edited by anyone, relying on the goodwill of others to correct errors or to remove unwanted content, but wiki users are now usually obliged to register before becoming contributors and this often acts as a deterrent to irresponsible behaviour[25]. It is also possible to have a closed wiki on an internal network, for example.

In the commercial environment, web developers increasingly use wikis to brainstorm initial ideas and see them through to a finished product or service. The strength of such a learning environment lies in the ability to reflect on, model and share new ideas. Some educators are beginning to use wikis in imaginative ways – as jump-off points for projects, brainstorming, language teaching and creative writing.

Blogs

The term blog[26] comes from weblog and, to quote Wikipedia again: 'A blog is a website for which an individual or a group generates text, photographs, audio files and/or links, typically but not always on a daily or otherwise regular basis. The term is a shortened form of weblog. Authoring a blog, maintaining a blog or adding an article to an existing blog is called "blogging". Individual articles on a blog are called "blog posts", "posts", or "entries".'

Although there are now literally millions of trivial and uninteresting blogs in existence, they really have to be seen in context. The more serious blogs are a result of considered professional opinion and are joined together by a consensus of online opinion in virtual communities. In education they can be used in a diversity of ways – from tools for staff professional development to students' personal portfolios. They are now used increasingly by prospective employers to gauge an individual's personal commitment to their profession in the commercial world and an informed and entertaining blog is a career plus. Blogs have been used extensively in academia for some time and are increasingly being used as a tool for courseware development and personalised learning – indeed, they are one possible future route for content in electronic portfolios. But what is really important about blogs is that they are not seen in isolation but as a small part of what is called the 'blogosphere[27]'. Many professional blogs are joined together using web aggregator services and likeminded professionals are aware of and react to each other's postings: often an uneasy consensus is reached or debate fired off via blogs, with each participant adding to the sum of opinion. The group often appears to moderate and reflect the whole. The use of blogs in education is more advanced in the US, but it is still relatively new as a medium for teaching and learning[28]. More recently, multimedia variants of blogs have begun to appear.

Moblogs

Moblogs – **mob**ileb**logs** – are blogs with photos taken and sent by mobile phones to dedicated websites. Much of their use has been fairly trivial and this technology has only appeared in the public arena in the last two years, although some educational projects are being trialled[29].

Vlogs

Vlogs[30]– videoblogs – are closely related to moblogs in that videophones can be used to post content, but some videoblogs have much higher production values and take far more time to produce using digital video cameras and complex post-production techniques. This is still very much a fringe activity in education, but new software and web services are making it increasingly easier[31].

Podcasts

Podcasting – audio broadcasting over the web – is probably the best known of these emerging technologies. It gets its name from the combination of i**Pod** and broad**cast**ing. Podcasting technologies have been around for some years, but only recently has the delivery mechanism of RSS made it possible to broadcast audio both to wider and more specialised interest groups. Podcasts in the UK education sector are still emerging and are usually highly localised. Many traditional uses of audio in education become far more effective via this mechanism. Students can broadcast audio diaries, commentaries and outcomes of writing for an audience or construct entirely new interactive learning experiences never before possible[32]. Teachers can broadcast lectures, course notes and interviews with authors and other experts[33].

RSS and aggregators

The online blog media involved (photos, video, audio) are now almost always tagged and wrapped in XML code that uses a syndication technology called RSS. RSS increasingly underpins much of the information flow on the web today.

It was a technical standard that went through several iterations and schisms, but is now the name of the process whereby we can disseminate personalised dynamic information quickly and easily. While it may originally have stood for 'really simple syndication', the acronym has now become synonymous for what it is – news and information dissemination and retrieval for personalised content.

With RSS, independent and corporate producers, bloggers and educationalists can ensure that consumers watch, listen to or read their content where and when they want. A web service called an aggregator can search for and pull down this highly pertinent content, archive and even play it on the end-user's computer. The latest incarnation of the iTunes software is an example of an aggregator, pulling down specialised music (and other media) content straight to an iPod. This information wrapped around and pointing to the media is automatically updated and pushed out to the consumer when the producer updates the site.

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In many cases the process of creating RSS is being automated and, used in tandem with learning platforms, presents a possible future scenario for disseminating highly specialised and personalised learning content. Educational resources can be indexed and distributed in a learning object network.

RSS is likely to come to the fore in education for three reasons:

1) As teachers' expertise with multimedia learning objects grows, they will be looking for a cheap, useful distribution network to populate their lessons and courses. RSS could provide this and the means to find people and services allied to these resources and also provide a 'push mechanism' for people to disseminate their resources on a just-in-time and archived basis for others – centralised resources can be tailored for localisation in courseware, for example, by tweaking and modification.

2) Syndicated educational content could be one future of resourcing, for being able to syndicate images, videos and weblogs easily and freely across systems and networks, and to update and archive them in real time as well as aggregate them and attach relevant tags, could be a very powerful way forward for online learning. This is especially true if the process is linked to peer-to-peer communication systems whereby the learners themselves produce content, tags and resources, and aggregate or reflect on the accumulation of knowledge around these. This has serious implications for staff resourcing, training, professional development and a host of other applications – especially in tandem with CMS (content management systems) or learning platforms.

3) Many educationalists working on similar projects in different institutions would find it useful to pull all those feeds together to get an overview of what resources and activities are present in the educational arena. RSS enables you to do this. An initiative to drop DIDA[34] materials into the free VLE, Moodle, is already under way[35].

There are tools such as superglu **[http://www.superglu.com]** that allow you to bring multiple RSS feeds onto the same web page. This could be used to:

- aggregate all of a student's production in one page
- bring a range of different search feeds together for easy viewing
- create a class site that aggregates whatever content feeds you are providing for students
- create a collaborative project site
- bring teacher lesson plans or ideas together on one page.

Peer-to-peer (P2P) and swarmcasting

The way content is conveyed along the network infrastructure is also changing. Peer-to-peer computing (or P2P) is not new – it is a practice that reaches right back to the early internet. P2P is direct communication or collaboration (mostly file sharing) between computers, where none is simply client or server, but where all machines are equals (peers). What makes P2P unique is not two nodes talking to each other as equals, but the type and (virtual) location of the nodes. Ordinary PCs, previously little more than web-page viewers, become active participants in the internet, despite their lack of fixed IP addresses.

The Cambridge company CacheLogic[36] shows that file sharing is currently the dominant generator of data traffic on the net, with volumes ranging between two and 10 times those of normal web traffic, depending on the time of day.

Skype[37] also uses P2P technology, as does the video-conferencing web application Festoon[38], which enables you to hold whole audio conferences online for free. Skype (like other VoIP applications) allows you to make telephone calls for free to other users online: it is free to use, making its money out of selling allied services – in this respect it is a Web 2.0 business.

The sharing of digital video using P2P technologies has become more commonplace, but an historic US legal decision made against Grokster and Streamcast networks, both makers of P2P software, concluded that there was 'substantial evidence' that the defendants had profited by promoting copyright infringement. This decision would suggest that anyone wishing to write P2P software with the knowledge and intent that it will be used for illegal file sharing, and promoting that fact, will fall foul of this law in the future.

The current situation with P2P may well rest with legal initiatives. However, programs like BitTorrent, which were written with the express intention of sharing larger files rather than with the intent to distribute illegal or copyrighted material, are achieving more prominence – especially in academia, where multimedia content is beginning to be distributed in this way.

This may well have a knock-on effect on the trend for more symmetric services in the future[39], as uploads will be more prominent than they already are. To quote a recent paper on P2P sharing, 'it's not a question of if, but when…' BitTorrent is a swarmcasting technology and it might be relevant here to point out what that is and what it does...

Swarmcasting enables web content, especially rich media (video) files, to be sent across the internet more efficiently than traditional routes. The content or original file is broken into much smaller packets, which are then distributed to any computers that have requested them.

Each machine's 'role', for want of a better word, blurs and the network simply changes into a grid or mesh of file-transfer nodes all working together to accelerate the file-transfer process. This enables people to disseminate and share large video files in a much faster and efficient manner than normal. Technologies like the BitTorrent[40] client were written to enable this. It will also enable democratisation of media making and distribution. In effect, large institutions may be able to run their own TV stations across the internet in-house but this is only just beginning to happen. With a high-definition digital video camera, a powerful computer and the relevant software, it is now possible to make your own feature films. This could enable personalised portfolios of multimedia content to be established.

This technology has implications for IPR (intellectual property rights) – it is quite easy to copy (rip) and make duplicates (burn DVDs) from files disseminated over the internet in this way and it will become much easier, quicker and more efficient as broadband connections become much larger.

4

New models of distribution

The way we view and produce multimedia content will change. Some institutions, notably the BBC, are anticipating this cultural shift and are already developing innovative solutions. The BBC iMP Player[41] is an application in development that offers UK viewers the chance to catch up on TV and radio programmes they may have missed for up to seven days after the broadcast, using the internet to download programmes to home computers. iMP uses peer-to-peer distribution technology to distribute these programmes legally. Seven days after the programme transmission date the programme file expires, using digital rights management (DRM) software, and users will no longer be able to watch it. DRM also prevents users from emailing the files to other computer users or sharing them on disc.

To accommodate these changes, the BBC has recently introduced the Creative Archive. This will eventually be a massive repository of past programmes, both audio and video, tagged, indexed and ready to be downloaded and used, subject to certain restrictions. The beginning of this process will be rapidly prototyped using a web application called Ruby on Rails[42] and the BBC will be issuing a public beta in 2006[43].

Programmes offered through the Creative Archive can be disassembled and remixed to make new media objects. But the project has problems with legacy IPR attached to music and performers in programmes and many items are incomplete because of this. However their licence to reuse content is closely based on that outlined in the Creative Commons[44] licensing system – which allows for various stages of reuse. The Creative Commons initiative was born out of the necessity to adapt to the sudden ability to use, re-master and *share* digital materials. It provides a legal mechanism to allow publishers to decide how their content can be used, distributed or reused. It is used on several sites that have media repositories.

Conclusion

All these emerging technologies seem to be enabling an online social networking system that appears to be effecting a cultural and procedural change in business and other allied institutions. How they can be harnessed and exploited in the educational arena has yet to be fully investigated and it will be intriguing to see which of the particular resources, systems and technologies briefly outlined here prove to be most effective in the near future. Even now some consolidation has occurred; Skype, Flickr and del.icio.us have all been bought up by larger commercial businesses.

It is difficult to peer into the future and predict with any certainty what may happen. But from the commercial credence that firms are putting on personalised data and tagging of information, it would suggest that similar innovations may be mirrored in the educational arena.

Integrated learning and management web-based systems should certainly offer far more scope for working within a personalised teaching and learning agenda. Students and teachers will have far more flexibility about how, what and where they learn.

Underpinning this, web connectivity is likely to become an 'always-on' utility like heat, light and water. How we choose to exploit these developments is still a matter of conjecture. But the one thing we cannot do is ignore them.

4

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The broadband home

Michael Philpott

Introduction

Broadband services and technologies are developing at an increasing rate. Just around the corner are technologies and services that will allow users to gain access to any content or application, any place and any time. They will also be able to store that content or application and retrieve it whenever and wherever they wish. The big industry push is largely around entertainment, as this is where the biggest revenue opportunity is currently envisaged. However, the educational sector can take full advantage of such technological and service developments. This article provides a summary of the latest trends in broadband access and broadband home networking in the UK.

What has this to do with education?

Information technology continues to be increasingly important in education – not just as a subject in its own right, but also as a key enabler in improving the teaching of other subjects. Broadband access, the home network and consumer electronic devices are helping to extend education both beyond the classroom and beyond traditional school hours.

Broadband access provides flexibility, convenience and innovative educational content right into the home. With the addition of mobility, broadband access will allow students to get access to content, their peers and their teachers whenever they wish and from wherever they wish.

This is not just limited to students either. It is well recognised that engaging parents in education benefits both parent and child. Broadband technologies allow parents to get more closely involved with the school and the child's education more regularly and from the comfort and convenience of their home or workplace.

Although PCs will still dominate how users connect to the broadband network for some time, devices such as the mobile phone, TV and smart phone will also offer ways for students to access educational services. Other devices, such as games consoles, may also play a role by providing a network connection between a PC and, say, a television set.

Shifts in broadband access

Broadband is becoming increasingly important to a number of different players and for a number of different reasons. For the telecommunications operators themselves, it is one of the few areas of predicted revenue growth and therefore success in this area is essential to the future of their business. For national governments, it is seen as key to both economic and social development.

Where we are today

Figure 1 **Broadband adoption in Europe**

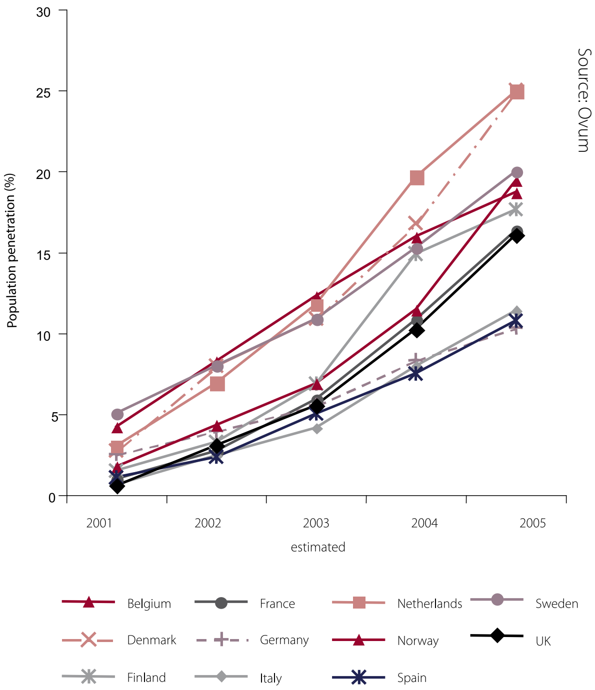
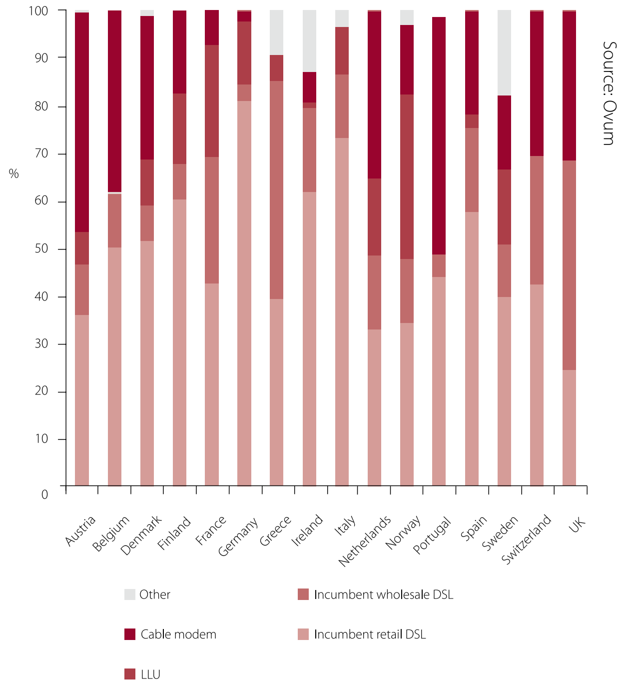


Figure 2 **Broadband competition in Western Europe (Q4 2004)**



It is therefore unsurprising that broadband has received a lot of interest from both public and private sectors over the past five years. However, broadband in the UK, as shown in Figure 1, was slow to take off and, although growing quickly, still lags behind France, Belgium, the Netherlands and most of the Nordic countries.

As shown in Figure 2, the UK market is now also one of the most competitive markets in Western Europe, with the incumbent's market share below 30%. However, until very recently, this competition had largely been provided at a retail level or via the cable companies NTL and Telewest, which have both had financial difficulties. This type of competition meant that users have had plenty of choice in terms of which ISP they prefer to deal with, but are actually restricted in terms of the broadband services they can choose from. Before 2005, for example, outside of a few lucky areas of the country it was impossible to get more than 2Mbit/s via DSL – only Telewest, with its 3Mbit/s service, offered higher speeds.

In 2005 this started to change as the cable companies became financially stronger and more aggressive, and as more companies entered local loop unbundling (LLU). LLU means that the ISP owns and controls everything apart from the copper pair connecting the user's premises to the local exchange building. ISPs are no longer reliant on the wholesale services that BT wishes to offer and are now only restricted by the physical capabilities of their network and the regulations put in place by the regulator, Ofcom.

Companies such as Easynet and Bulldog (owned by Cable & Wireless) offer 8Mbit/s on exchanges they have already unbundled and Easynet also offers wholesale services to other ISPs so that these may do the same. The cable companies have reacted to this and in 2005 launched their own higher-speed services of 10Mbit/s. Such market developments will continue over 2006 as competition continues to intensify.

The future for broadband in the UK

The UK market is in a transitional period. With LLU, greater competition is entering the market at a network level and services up to 24Mbit/s are already coming online in certain parts of the country.

The merger between the cable companies NTL and Telewest will result in a stronger competitor across the board. Both companies offer 10Mbit/s and, with the current technology in place in the network, this could increase up to the 20Mbit/s level – although some of the older customer premise equipment (CPE) will have to be replaced. With newer technology, known as DOCSIS 2 and DOCSIS 3, rates could be pushed beyond this to 30–35Mbit/s.

BT itself is rolling out its 'next-generation' network known as the 21st-Century Network (21CN). This is an all-IP multi-service network, which will enable the provision of ADSL2+ technology to nearly every household in the UK. Deployment has already started and most of the network should be covered by 2010. From a wholesale point of view this network will become important, as it will allow ISPs to offer higher speeds and quality assurance to customers beyond their own LLU footprint.

LLU really only makes sense in denser areas because the business case for deployment is all about cost per customer, and the more customers ISPs can connect, the cheaper it becomes. Realistically, therefore, the UK is unlikely to see LLU spread beyond the top 1,000 of BT's 6,000 local exchanges in the foreseeable future. Currently customers outside of an ISP's LLU footprint (which may be quite small) are not able to receive the same level of service offered to those within the footprint, as it is restricted by BT Wholesale's capabilities. The 21CN will greatly improve this – perhaps to a level where there will be no discernible difference between service levels across the country.

More emphasis on broadband services

Much of the increase in speed in the UK, and in Europe in general, has initially been done for marketing purposes. It is seen as a good way of capturing new customers and retaining existing ones. It has become preferable to price reduction because by offering more bandwidth for the same price, telecoms companies maintain average revenue per user (ARPU) levels, an important benchmark for measuring company performance used by the financial community. However, behind the marketing lies a further strategy – ISPs are progressing beyond offering simply broadband access and are increasingly launching premium services such as music, gaming and video/TV, for which high speed is required. Figure 3 shows the speed requirement for some typical broadband applications

Figure 3 **Bandwidth requirements per application**

Application	Downstream	Upstream
VoIP	80kbit/s	80kbit/s
Video telephony	124kbit/s to 2Mbit/s	124kbit/s to 2Mbit/s
Online gaming	256kbit/s	256kbit/s
TV channel (MPEG2)	3–4Mbit/s	Signalling only
TV channel (MPEG4)	1.5–2Mbit/s	Signalling only
HDTV channel (MPEG2)	18–20Mbit/s	Signalling only
HDTV channel (MPEG4)	6–8Mbit/s	Signalling only

Source: Ovum

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So, in order to use a bundle of services including multi-channel TV, VoIP, gaming and internet surfing, users will need an access speed of 10 to 20Mbit/s. However, simply bundling services is not going to be enough for operators to differentiate, as eventually all major players will offer roughly the same service. Therefore in 2006 we will see a rapid increase in innovation and investment in consumer services and devices.

Current innovation is focusing on two areas: service integration and service flexibility.

- Service integration – actually integrating services, rather than simply bundling the tariffs – can provide some innovative and valuable services. Operators will try and turn this perceived value into additional revenue, and users can therefore expect to be charged for some of this innovation. Examples of service integration include:
  - Integrating TV and VoIP so that the user can watch a programme and conduct a voice/instant messaging session at the same time
  - Providing certain broadband services on the TV, such as photo sharing, email and internet browsing
  - Purchasing products via the TV and downloading them instantly onto another device in the home.
- Service flexibility – making traditional services more flexible – also adds value and is believed to be probably the greatest opportunity for service providers to increase revenues. Flexibility is currently being developed for TV services to allow users to watch programmes on demand at a time of their choice, and to obtain the same services as in the home when on the move. Flexibility is a great asset, but certainly one for which users will be expected to pay a premium.

Shifting goal posts for broadband equality

It is important to note that these advanced services will not be open to all, and that the UK is moving to a new broadband divide built around speed. Originally the broadband divide was about those that could not get access to any type of broadband service because they lived in rural or more deprived areas. The new divide will not be between those who can and those who can't, but will be around what level of service they can receive.

Advanced services require more bandwidth. A number of DSL-based ISPs have recently launched high-speed DSL access services and the incumbent, BT, will follow suit soon. However, one of the major issues with DSL is that the further away the user is from the local exchange, the less speed they are able to obtain. In fact, in the current UK network, only about 45% of households will be able to receive 8Mbit/s or more, and it is likely that only 5% of homes will be able to receive the maximum 24Mbit/s that ADSL2+ can offer. The cable networks fare better, as they are newer and have much shorter copper loop lengths, but these networks cover only 50% of homes and there will be significant overlap between the cable networks and the parts of the DSL network with the shortest DSL loops.

The only way to resolve such issues is to migrate to more optical fibre in the access network – known as fibre-to-the-home (FTTH) or fibre-to-the-node (FTTN). However, owing to cost and regulatory issues, we do not expect to see deployments of this nature in the UK in the short term.

As broadband access is still predominantly built around the PC as the end-device, there is a certain proportion of households – about 30% in the UK – which cannot get broadband services because they do not own a PC. However, this proportion will reduce over time. Allowing other devices – the TV perhaps – to connect to the broadband network, will enable such households to access some broadband applications. As operators and ISPs are still concentrating on the PC-enabled market, we do not expect such services to hit the UK market until at least 2007.

The importance of the home network

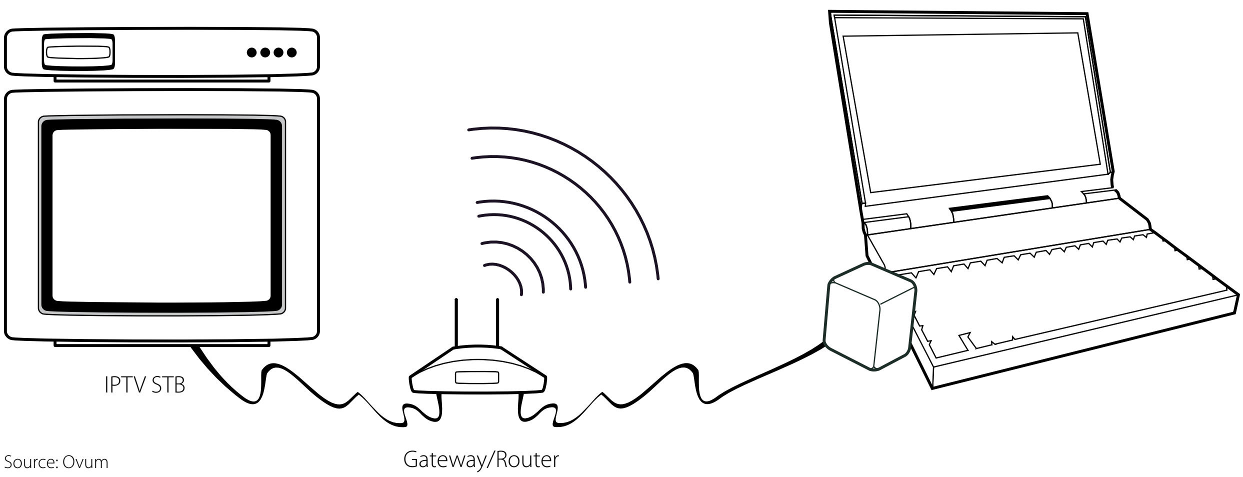
Home networking has become one of the hottest topics around in the technology world as users wish to be able to receive and share certain services and applications on devices in the home other than the PC. Operators and vendors of equipment and devices are happy to oblige, but it raises many technical issues that must first be resolved if home networking is going to be simple and inexpensive for users to set up.

Home networks are hardly new and are already evident in many homes. People use home networks today primarily for data communications – for example, to share an internet connection between multiple PCs, to transfer data from one PC to another or to transfer data from a PC to a peripheral device such as a printer. Yet multimedia home networks that are capable of delivering many different types of media from a single integrated network to a whole range of different devices are certainly new. Their development provides some major challenges to network operators and consumer electronics vendors alike, and therefore will develop slowly over a period of years.

The first step for many network operators is to extend the data network to include the TV. The standard network architecture for this today is shown in Figure 4.

The architecture consists of a home gateway/router device that is physically connected to the network termination point and the IPTV set-top box (STB). PCs can then be connected using Wi-Fi technology for internet access. The reason the STB is hard-wired rather than using Wi-Fi is because the current 802.11 standards cannot guarantee the same level of bandwidth throughout the home and the quality of service mechanisms are still not good enough for high-quality video services.

Figure 4 **Today's standard home network for IPTV**



Source: Ovum

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The forthcoming 802.11n standard will solve both these issues, but has not yet been finalised, and therefore is not present in current STBs and routers. HomePlug, a network technology that uses the mains wiring, is another candidate. However, there are still questions around the maturity of this technology and issues with radio interference remain. MoCA (Multimedia over Coax Alliance) is a good solution, but is only applicable in countries where pre-cabling houses with coax cable is popular, and this does not include the UK. However, until a mature solution is available, operators will have to make do with the architecture as shown in Figure 4.

Getting to this point is not easy for network operators, as it requires a level of management that they have not experienced before in the consumer segment. Reaching beyond this, therefore, to include games consoles, mobile devices, video devices and music systems, complicates the picture to a point that is currently beyond the capabilities of most operators. Yet connecting and managing such devices, in addition to delivering services, is going to be essential if network operators are to play a key role in the future of the broadband home.

Some of the major issues preventing the widespread take-up of these technologies include the following.

- There is little standardisation – most devices in the home work on proprietary technology, which limits communication between them. This leads to confusion and frustration for the user as they either become unsure of which device to buy, or cannot get the devices to work in the way that they want once they have bought them. This can become costly for the operator who can sometimes bear the brunt of the service calls.
- Communication between devices becomes even harder if the devices are designed for different purposes. For example, it can be difficult for a user to take music they have recorded on the TV and play it on a music system in another room. Breaking down these barriers will be essential if flexibility and true mobility are to be achieved.
- Set-up can be complicated: many devices are still hard to configure. There may be more 'plug and play' these days for the basic operation, but to get to the full feature set the user often has to be an expert in either IT or IP. This is a fundamental issue that must be resolved if the industry as a whole is to move forward.
- Maintenance is a problem: getting devices up and running is one thing, but fixing them when faults occur is even harder. Device support is obviously available, but in the future it is going to become increasingly difficult for the user to work out where the problem lies.
- Digital rights become restrictive – digital rights management (DRM) is obviously essential, but can become increasingly annoying for consumers if it limits their use of material in ways that they consider perfectly reasonable.

Drivers for the broadband home from the consumer electronics industry

On the whole, the motives of consumer electronics vendors are easy to understand – they wish to sell more boxes, more chips that go in boxes or more software that empowers boxes. There are some exceptions to this, such as Intel, Microsoft and Sony, which have branched out into different sectors, but even they have this fundamental drive. For such players, therefore, broadband and the broadband home represent a new – or at least expanded – market opportunity.

However, vendors face a dilemma. To stimulate markets further, a certain amount of standardisation is required. Vendors thrive off proprietary technology in order to differentiate against the competition. Moving to a more standardised and open world can be a hard pill to swallow, even though it could help them in the long run. Vendors are starting to see the value in creating more open solutions, but it is still going to take time to break down some of the old barriers.

One organisation that is working towards a better and more flexible future for the broadband home is the Digital Living Network Alliance (DLNA). The DLNA is made up of over 240 consumer electronics companies and is headed by some of the most powerful companies in their industry such as Sony, Samsung, Microsoft, Intel and Philips. The vision of the DLNA is to create interoperability between wired and wireless devices of all types, so that content of any nature can be shared between them in a seamless fashion. They do not create standards as such, but use existing standards to create design guidelines. The idea is that if a vendor has followed these guidelines, their items will obtain an industry stamp to show that they will work with other equipment with a similar mark.

Many vendors are influenced by this work and you can often see this influence in their own product roadmaps. However, most products are still focused on communication with the internet, standard devices such as PCs, and then within their own product range or those of their close partners.

Developments are rapidly progressing and in 2006 consumers will see a number of new products and services hitting the high-street stores. The following initiatives come from just three household names.

- Microsoft has already launched its Media Centre PC and TV system, Europe should see Extender devices in the shops in 2006, and Xbox 360 was launched in Europe in early December. We also expect Microsoft to develop its 'play-for-sure' branding and partnerships further, as well as continue its work in the DRM sector, which includes such features as 'secure clock'. This allows content to be shared to other devices but automatically deleted after the allotted time.
- In January 2006 Intel launched its Viiv platform optimised for media/entertainment PCs with such functionality as instant on/off, remote control and internal DRM that allows content to be shared regardless of whether the device is capable of supporting the original DRM format.
- Philips has its Connected Planet brand and its strategy for home networking that allows the user to gain access to content wherever they are in the home by streaming content from a central server or over the internet to other devices connected via Wi-Fi. Philips also has some big deals with large broadband operators in the pipeline, supplying BT with its IPTV STB in mid-2006 and working with another player on co-branded plasma TVs.

Such technological developments, together with the push from broadband operators for services as well as standardisation, mean that the ways in which consumers use and access content and entertainment will rapidly change.

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The future for the home network

As a number of organisations – from telecommunication operators to content providers and from consumer electronic vendors to retailers – start to focus on the broadband home network, the rate at which the network will develop will increase, but how it will develop is as yet uncertain. If anything, the picture will become more clouded for the user before it becomes clearer.

This is because all the different players have essentially the same vision, but are going about achievng it in different ways. For example, it is commonly believed that there needs to be a central device in the home that brings the whole network together and provides the user with some sort of control. However, there are currently five suggested devices – the PC, the router, the STB, the mobile phone or a specific remote control – that could provide this functionality. In reality, there will be more than one and it will be down to the user to make the decision; and, with intense marketing pressure from the different stakeholders, this is unlikely to be easy. Similar decisions will have to be made around issues such as storage, security and network management.

Today only about 8% of UK households have a data home network. The main purpose of these networks is to share internet connections or to get data from one PC to another PC and peripheral devices such as printers. However, as the number of electronic devices that can be connected together in the home increases, the user's desire to connect and share data between devices will also increase. Technology to enable greater integration and communication is developing rapidly, although customer adoption of it, especially in the mass market, will be much more gradual.

For the time being, therefore, the PC will remain at the centre of the home network. Desktops are still by far the most popular version, although there is now a greater interest in laptops as their price reduces and the functionality improves. Media PCs, which are designed to fit better in the living room, are also coming onto the market and, although the market is immature today, it will play an increasing role in the future. Entertainment devices such as the TV and the music system are of course being added to this network, but the integration of different services and devices is still limited at present. The first signs of this are starting to appear. For example, NTL has recently announced a photo-sharing service on its TV platform, and BT has announced that it will include VoIP and instant messaging (IM) features on its IPTV service, which will be launched in mid-2006. Gaining the full features of what is available on a PC today on other devices such as a TV or mobile phone is still a long way off.

Stepping out of the home

Mobility is a key part of broadband operator strategies and of the broadband home. It is envisaged that in the near future many, if not all, the services that users can currently access in the home will also be available on the move, but in a different format and different quality. Users will be able to access network content and applications, but also content that they already have stored on their home devices. This will present the user with a truly ubiquitous broadband experience, providing full flexibility and 'anytime, anywhere' access to broadband content, applications and services. Users will start to see some initial services being offered towards the end of 2006.

Advantages for education

Access to educational content, services and support over broadband – and particularly the institution's learning platform – from home or while on the move will be key to providing flexible, personalised learning at a time and place that suits the learner. There is an increasing range of devices capable of accessing such content and services; and the traditional boundaries between the computer and consumer electronics worlds and between the fixed and mobile worlds are blurring. In the future, learners are likely to use a variety of connected devices and carry out personal, entertainment, communication and learning activities on all of them.

Glossary

3G
Third-generation mobile telephone networks, which in the UK are based on wideband code division multiple access (W-CDMA). This is the next-generation successor to GSM networks, currently allowing download speeds of up to 384Kbps and providing more network capacity. All the major mobile phone companies have launched 3G services, but coverage remains limited.

4G
Fourth-generation mobile phone networks are still in development. They are expected to be IP based and allow seamless roaming between different kinds of networks. The International Telecommunication Union (ITU) specification for 4G services are for data rates of 1Gbps with a stationary client and 100Mbps with a moving client. 4G services are expected to appear around 2010–15.

802.11
Institute of Electrical and Electronic Engineers (IEEE) standards for wireless local area networks (WLANs), more commonly referred to as Wi-Fi (see below). Currently 802.11b (11Mbps), 802.11g (54Mbps) and 802.11a (54Mbps) are the main standards. 802,11b and 802.11g work in the 2.4GHz frequency, and 802.11g is backwards compatible with 802.11b. 802.11a works in the less crowded 5Ghz frequency range and is not compatible with the other two standards. The 802.11n, standard, which is yet to be ratified, should allow real-world data rates exceeding 100Mbps. There is also a range of other 802.11 standards such as 802.11i – wireless security – and 802.11e – QoS (see p56) for wireless networks.

ADSL2+
Asymmetric digital subscriber line (ADSL) 2+. ADSL is currently the most common form of broadband internet access technology in the UK. It provides broadband connectivity over existing telephone infrastructure, with the uplink speed being lower than the download speed (asymmetric). ADSL2+ is a newer version of this technology that should allow connection speeds of up to 24Mbps where conditions allow (depending on proximity to telephone exchange).

Avatar
Graphical representation of a person used in computer applications, particularly for communication.

Blog
Web log (blog): an online journal/commentary with simple automated content-creating facilities, links and response mechanisms. Blogs often use RSS (see below) so that readers can subscribe and receive new content as it is published.

Bluetooth
A short-range wireless technology. It is mainly used to connect devices and peripherals such as mobile phones, headsets, printers and cameras. The most common Bluetooth standard has maximum data rates of 721Kbps, but the newer Bluetooth 2 (Enhanced Data Rate) allows for speeds up to 2.1Mbps.

CF
Compact Flash: a type of removable Flash memory card.

CPE
Customer premise equipment: the hardware needed in homes or businesses to gain access to services (wireless broadband access points, for instance).

Creative Commons
A licensing system developed by Lawrence Lessig and others at Stanford University. Creative Commons (CC) licences allow a content creator to decide how published work may be copied, modified and distributed. UK versions of the licence are now available.

DOCSIS 2/3
Data over cable service interface specification: a high speed connectivity standard for cable modems and set-top boxes (STBs).

DRM
Digital rights management: the protection of copyrighted digital content to prevent unauthorised viewing, copying or distribution.

DSL
Digital subscriber line: the technology used to deliver broadband internet access over telephone lines. There are various types of DSL including asymmetric (ADSL), symmetric (SDSL) and very high bit rate (VDSL).

E-portfolio
An e-portfolio is a digitised collection of documents and resources that represent an individual's achievements. The user can manage the contents and usually grant access to appropriate people. There is currently a variety of different types of e-portfolio with varied functionality. E-portfolios are increasingly being used for coursework and other assessment purposes.

FireWire
Also known as IEEE 1394. A high-speed connection interface used for connecting digital video cameras, hard drives and other peripherals with computers. The term FireWire is particularly associated with Apple computers.

Folksonomy
Derived from folk + taxonomy, a Folksonomy is a way of categorising data on the web using tags generated by users. Folksonomies are used on collaborative, 'social' websites for photo sharing, blogs and social bookmarking. Social bookmarking websites are services that allow users to store their favourite websites online and access them from any internet-connected computer. Users tag their favourite websites with keywords. These are then shared with other users and build into folksonomies of the most popular sites arranged under different categories.

GPRS
General packet radio services, and sometimes referred to as 2.5G: an update to GSM mobile phone networks that allows for faster data downloads. GPRS is also being used to fill in gaps in 3G coverage (see previous page).

GPS
Global positioning system: a satellite-based location technology that can determine position down to a few metres. GPS modules are used for in-car navigation and in handheld navigation devices, and can be added to PDAs and laptops. Location-based services that make use of the technology are being developed for education.

Haptics
Haptic technologies are those that use touch or sensation in the human-computer interface (HCI). Examples are force-feedback games controllers and virtual-reality gloves that allow the user to 'interact' with a virtual environment.

HDTV
High-definition television: current UK PAL standard-definition television has a resolution of 625 lines (although not all the lines are used for the picture). High-definition TV has a much higher resolution. There are two main standards: 1080i (interlaced) and 720p (progressive scan), 1080p is also available. Some HDTV services are expected to launch in the UK in 2006.

HomePlug
The HomePlug Alliance develops standards for networking over electricity cabling in the home.

HSDPA/3.5G
High-speed downlink packet access: also known as 3.5G, an upgrade to 3G networks. It allows for download speeds of up to 14.4 Mbps, although actual services are expected to be much lower than this. HSDPA will begin to roll out commercially in 2006. HSUPA (uplink) will follow later.

IPTV
Internet protocol television: television/video delivered over broadband to PCs or set-top boxes (STBs).

ISP
Internet service provider: the company that provides a user with access to the internet and other services.

Learning Platform

'Learning platform' is a generic term to describe a broad range of ICT systems which are used to deliver and support learning. A learning platform usually combines several functions, such as organising, mapping and delivering curriculum activities and the facility for learners and teachers to have a dialogue about the activity, all via ICT. So, the term learning platform can be applied to a virtual learning environment (VLE) or to the components of a managed learning environment (MLE). A VLE is a software tool which brings together resources for curriculum mapping, delivery, assessment, tutor support, communication and tracking. A managed learning environment (MLE) refers to the whole range of information systems and processes that support learning and the management of learning within an institution. It includes VLEs or other learning platforms, administrative and other support systems.

LLU

Local loop unbundling: the process under which telecoms operators install their own equipment in BT exchanges and supply services directly to customers.

M-learning

Mobile learning: learning delivered through mobile devices.

MMS

Multimedia messaging service: a network service that allows mobile phones to exchange photos and other files.

Moblog

A blog posted to the internet from a mobile device.

MoCA

Multimedia over Coax Alliance: a non-profit organisation concerned with developing and promoting specifications for carrying digital entertainment and information content over coaxial cable in private homes.

NFC

Near-field communication: a short range, peer-to-peer wireless interface protocol for easily setting up connections between devices. Once the initial connection has been established, faster and longer range protocols such as Wi-Fi can be used to exchange data.

PCMCIA slot

Personal Computer Memory Card International Association: PCMCIA is a standards body that defines standards for PC/ExpressCards and interfaces that are used to add extra memory or functionality to devices such as notebook computers.

PMP

Personal media player: a mobile device, with built-in colour display, that can store and play a variety of media files such as photos, video and music.

Podcast

Podcasts are audio files that can be easily distributed via the web and downloaded to computers and personal audio players. Podcasts are often syndicated so that users can subscribe (usually for free) to a particular service and have new content automatically downloaded. The software required to produce and distribute podcasts is available for free or at little cost, making this form of 'broadcasting' extremely accessible.

Presence

Functionality in certain applications, such as instant messaging programs, that allows users to know the 'state' of their contacts – whether they are online, if they are busy or not and possibly which form of communication they can be contacted by.

PS/2

Personal System/2: a computer interface standard for keyboards and pointing devices such as mice.

QoS

Quality of service: network services that support prioritisation of traffic to provide better throughput.

RFID

Radio frequency identification: a generic term that refers to wireless technologies that are used to provide information about a person or object. The term has been popularised with the emergence of RFID tags: inexpensive, miniature wireless chips with antennae that can be embedded into objects.

Router

A network device connecting two or more networks, such as a local area network (LAN) with the internet.

RSS

Really simple syndication: a set of XML-based specifications for syndicating news and other website content and making it machine readable. Users who subscribe to RSS-enabled websites can have new content automatically 'pushed' to them. This content is usually collected by RSS-aware applications called aggregators or news readers. Some web browsers now have these news readers built in.

SD

Secure digital: a removable Flash memory card format primarily used with digital cameras and handheld computers.

Semantic Web

The Semantic Web is being developed to allow devices, information services and applications to interact directly with each other dynamically over the web.

Smart card

A smart card is a credit-card-size device with an embedded microchip. There are two main types of card: contact and contactless (proximity). Contact smart cards, such as the new chip-and-PIN credit cards, need to be inserted or swiped through a reader. Contactless smart cards use short-range radio that allows them to be read when they come close to a reader. These are often used for door entry systems, taking attendance in schools, cashless catering and a range of other services such as transport systems (London Underground Oyster Card, for example).

Smart phone

A mobile phone that includes PDA-like functionality. They tend to be more powerful than standard phones, with larger screens and expansion slots for memory cards. Applications can be installed on the phones.

STB

Set-top box: the device that gives access to digital television services such as satellite television, IPTV or Freeview. STBs are becoming more sophisticated, with built-in hard drives and network functionality.

Terabyte (TB)

A data storage capacity term meaning about 1,000 Gigabytes.

UWB

Ultra wideband: an emerging, high data rate wireless technology. Intended to provide high-speed wireless connections over short distances, it is expected to be used for cable replacement applications and for multimedia networking in the home. However, the IEEE 802.15.3a standards process for UWB has now been halted as agreement between rival solutions could not be achieved. Devices using the two incompatible solutions are expected to come to market in 2006. The first implementations should be wireless versions of USB 2.0. UWB has not yet been approved for use in Europe.

Vlog

A blog based on video content.

VoIP

Voice over Internet Protocol (IP) is a technology that breaks voice communications into packets that can be sent over IP networks such as local area networks (LANs) or the internet. This has advantages in terms of cost savings and increased functionality/manageability.

Wi-Fi

A term that is used generically to refer to wireless networks based on the IEEE 802.11 standards. However, Wi-Fi actually refers to products certified as being standards compliant and interoperable with other Wi-Fi devices. This testing and certification is carried out by the Wi-Fi Alliance, a not-for-profit industry body.

Wiki

Wikis are collaborative web pages that can be viewed and modified by anyone with a web browser and internet access.

WiMAX

WiMAX is a high-speed wireless technology based on IEEE 802.16 standards. It is intended to provide wireless broadband coverage over a large area. As with Wi-Fi and 802.11, WiMAX is the industry body that tests and certifies products as being standards compliant and interoperable with other WiMAX devices. There are different standards for fixed/nomadic and fixed/mobile access. The first WiMAX implementations, based on 802.16-2004 (fixed), are expected to provide a wireless alternative to DSL and cable broadband internet access. WiMAX base stations are likely to cover cells of 3–10km with maximum speeds of 40Mbps (shared between all connected users in the cell). A mobile version of WiMAX (802.16-2005), incompatible with the fixed version, should eventually provide WiMAX connectivity to a variety of devices such as notebooks, PDAs and mobile phones. Mobile WiMAX cells are likely to provide 15Mbps in cells of 1–3km. Currently, several companies have launched 'pre-WiMAX' services using equipment not yet certified by the WiMAX Forum.

WLAN

Wireless local area network.

XML

Extensible Markup Language. XML is a flexible, text based markup language for describing structured information.

ZigBee

ZigBee is a wireless sensor network technology specification based on the IEEE 802.15.4 standard. The ZigBee Alliance is a trade body that oversees testing and certification for ZigBee products. ZigBee is intended to be a low-cost, low-power, low-data-rate wireless networking standard for sensor and control networks. The technology will primarily be used for industrial and home sensor networks and building control systems, such as security systems, smoke alarms, and heating and lighting controls. ZigBee-enabled products can create mesh networks, routing traffic via other ZigBee devices.

Further information

Becta s view: Emerging technologies

Becta s view: Interoperability of content and data services

Becta s view: Assistive technology

Becta s view: Authentication

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Becta
British Educational Communications and Technology Agency

British Educational Communications and Technology Agency (Becta)

Millburn Hill Road, Science Park, Coventry CV4 7JJ

Tel: 024 7641 6994
Fax: 024 7641 1418

Research email: research@becta.org.uk
Main email: becta@becta.org.uk
URL: www.becta.org.uk

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