Disruptive Ubiquity?

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This paper was originally written in late 2004 to May 2005, as a journal article following the Colston Symposium (see below) and was accepted, pending revisions, for publication. At the time I was simply too busy on new projects to re-edit it and now two years after the event it's probably a bit late.

However it's a paper that contains ideas that I think are interesting and worth sharing even in this relatively unrefined from. So I've decided to make this copy available via my personal homepage:
http://www.ilrt.bris.ac.uk/~edxps/publications/disruptive-ubiquity.pdf

Feedback always welcome.

Abstract

This paper is based on a presentation given at the Colston Symposium 2004 at the University of Bristol. The presentation aimed to stimulate debate and discussion within the framework of the symposium by introducing *ubiquitous technologies* as an example of potentially *disruptive technologies* (Christensen) in an educational context. It highlighted that while individual examples of ubiquitous technologies may have significant impacts, by combining them the impacts may be greater still. This paper has attempted to continue this theme. It argues that ubiquitous wirelessly networked computing and 'convergence' are not only buzzwords, but are already redefining social and educational relationships in a 'disruptive' manner. They challenge our education system from without, as the outside world becomes more saturated with wireless technologies and services, and from within by offering new educational affordances that existing frameworks seem often ill suited to integrate. It observes that as technological development cycles shorten, the challenges of making effective use of new technologies within formal educational contexts increases. Finally it revisits the ideas of disruptive technologies from Christensen and asks if there are lessons for education from the experiences of companies dealing with disruptive technologies in their markets.

Introduction

This paper builds on a presentation given as part of the Colston Symposium 2004, held at the University of Bristol, in March 2004 (Shabajee 2004). The symposium aimed to "… *bring together researchers from a number of disciplines such as computer science, education and other social sciences to bring their perspectives to bear on both evolving technologies and modes of learning*." (Colston Symposium 2004).

The motivation behind this goal being that, "… *human and technical strands of research are still largely undertaken within separate disciplinary 'silos'. Technical researchers may develop technologies which could have huge impact but without a clear idea of potential application, whilst education researchers may encounter problems that, without an understanding or interest in the technology, fall short of solution… In order to harness the knowledge from these various cultures and perspectives and begin to develop shared understandings, we need to provide opportunities for researchers to come together for discussion and debate."*

The particular presentation on which this paper is built had three objectives: 1) to provide an overview of a range of existing and rapidly evolving digital technologies that as yet have had little impact on mainstream educational practice; 2) to stimulate debate and discussion within the framework of the symposium and 3) to introduce the use of instant messaging and blogging facilities available to delegates at the Symposium (see Colston Symposium below). This paper continues with the first two of these. It begins by introducing the two central concepts that make up the title of this paper, those of *disruptive* and *ubiquitous technologies*. It goes on to present an overview of these technologies and examples of existing educational applications. The final sections lay the foundation for debate by arguing that such technologies disrupt educational practice from a) within, by providing new educational affordances that may challenge traditional practices and b) from without, as the introduction of ubiquitous technologies bring about wide-ranging change in the wider society within which the school system resides.

Defining Disruptive and Ubiquitous Technologies for Education

Disruptive Technologies

The term 'disruptive technology' was coined by Clayton Christensen in his book, The Innovator's Dilemma (Christensen 1997). The concept, while born of an analysis of commercial organisations, can be seen as having wide applicability and is used here to highlight issues related to innovation in an educational context.

It is helpful to begin with a brief review of Christensen's concept of 'disruptive technologies'. He notes: "*Disruptive technologies bring to a market a very different value proposition than had been available previously. Generally, disruptive technologies underperform established products in mainstream markets. But they have other features that a few fringe (and generally new) customers value. Products based on disruptive technologies are typically cheaper, simpler, smaller, and, frequently, more convenient to use...*"

These technologies are broadly defined by having new step changes in features, valued by a few fringe customers. They are contrasted with *sustaining technologies* that are based, broadly speaking, on incremental improvements to an already established technology.

The *innovator's dilemma* is simple to state; it is that the "*logical, competent decisions of management that are critical to the success of their* [market leading] *companies are also the reasons why they lose their positions of* [market] *leadership* [in the face of potentially disruptive technologies]". That is, for large successful companies, it does *not* make business sense to invest in products that are low profit, provide low (often retrograde) value offerings to [their existing] customers, and only cater to fringe markets. And yet in some small number of cases they may find that their own products or services are displaced by these very technologies as they develop – a process that can be very rapid.

The success of disruptive technologies is often enhanced because they side step traditional business rules and can therefore undermine existing and dominant technologies within their own marketplaces e.g. by allowing those with relatively low levels of capital or skill to produce products or access services that were previously only available through (generally expensive) specialist companies or organisations. For example, in historical terms, the printing press displaced manuscripts and today community-maintained and freely available information resources such as Wikipedia (2004) might be seen as beginning to displace authoritative encyclopaedias.

A more informal but possibly more widely-used use of the term *disruptive technology* extends this market-focused definition to describe the wider impacts. An example is given by Thornburg (2004) to introduce a talk on '*Disruptive Technologies in Education'*. He states "*Every so often a technology emerges that transforms the world that created it…*". This more informal use tends to characterise the 'disruptive' impacts of *disruptive technologies* on society as a whole. Widely used examples of such disruptions include innovative technologies that have historically had very significant impacts on wider society, such as rail transport and the printing press. As such it echoes other popular conceptualisations of the impact that technologies have on humans as individuals and as societies as a whole by, for example, McLuhan Marshall (1967).

In the context of education it is the latter, more general meaning that seems to be dominant. It is not so much the *market* that is the focus, but the disruption of 'traditional' practices and processes of education, by or through the introduction of technologies, although the concepts of the narrower, market-focused definition is implicit in this wider use of the term. Indeed the disruption of existing markets [for products or/and services] is a prerequisite for such large-scale disruption.

Ubiquitous and Pervasive Technologies

The term *ubiquitous technology* was coined by Mark Weiser in 1988 at the Computer Science Lab at Xerox PARC (Weiser 1996). As Weisner argued "*… the vision of laptop machines, dynabooks and "knowledge navigators" is only a transitional step toward achieving the real potential of information technology. Such machines cannot truly make computing an integral, invisible part of the way people live their lives. Therefore we* [Weisner and colleagues at PARC] *are trying to conceive a new way of thinking about computers in the world, one that takes into account the natural human environment and allows the computers themselves to vanish into the background"*. Weisner (1991).

More recently the term *pervasive computing* has come to be used synonymously with the Weisner vision of *ubiquitous computing*. As the introduction to IEEE Pervasive Computing journal puts it, "*The essence of this vision is the creation of environments saturated with computing and wireless communication, yet gracefully integrated with human users." (ieee_2005IEEE 2005).*

However, the term 'ubiquitous' is sometimes used differently. It is not uncommon to see the term used in a more restricted sense in educational contexts. For example, "*By ubiquitous computing, we mean… carrying a personal computing device with you and using it as a personal, dedicated resource without restrictions*." (Perry 2003b p14).

In this paper, I use both terms largely interchangeably. However *ubiquitous* will be used to imply more of the sense of 'computers everywhere' in use today (e.g. Personal Digital Assistants (PDAs), mobile computer/phones, etc.) rather than the deeper and longer term vision of making computers disappear into the fabric of our environment and personal world. A concept that is perhaps more intuitively denoted by the term *pervasive*.

Today there are a multitude of ubiquitous and pervasive computing products, applications, projects and services around the world. In his book 'Smart Mobs', Howard Rheingold (Rheingold 2002) provides a wide-ranging overview and introduction to many of these technologies and their applications in many areas of daily life. The following section briefly reviews some of the key disruptive ubiquitous and pervasive technologies and the interplay between them, and gives examples of existing educational applications and initiatives.

Illustrations of Ubiquitous and Pervasive Technologies and Education

Wireless & Mobile Networking

The Internet and in particular the e-mail and the Web are disruptive technologies in all senses of the word; in market terms email has very significantly disrupted the traditional postal market and in turn changed the personal and business interactions of people across the developed world. The Web was 'born' in approx. 1990 (Gillies and Cailliau 2000), and the first 'Internet' e-mail in the early 1970s. In that short time they have had a radical impact at all levels from person to person communications to global markets.

However it is with the advent of newer and large-scale *wireless* technologies that richer mobile (and thus more ubiquitous) access to the Internet and its information and services have come about. There are a number of different wireless technologies that are in widespread use (Furht and Ilyas 2003). The most common includes WiFi allowing laptop and other mobile devices to link to computer networks via access points, increasingly available in public places, offices and homes. Mobile phone networks also provide access to Internet and other multimedia communications from nearly anywhere in the UK. The Bluetooth short range (10-100m) system allows the creation of *personal area networks*, joining together computer-based devices such as laptops, printers, keyboards, and mobile phones, allowing them to share and transfer any kind of digital information.

The combination of these networking technologies and increasingly miniaturised computing devices leads naturally to handheld mobile computer platforms. These increasingly combine the capabilities of multimedia laptops and mobile phones. This means that many of us are permanently surrounded by wireless signals and can tap into them *at any time*; access rights and costs not-with-standing.

This network of devices is the foundation on which many different types of communication and flows of information take place. These include: email; the Web (including access to information of all kinds including live news, radio and in some cases TV, online shopping and banking); Instant (multimedia) Messaging (IM); Blogging (Shabajee and Price 2004), text based chatting via systems such as IRC (Internet Relay Chat); mobile phone texting; Peer to Peer file sharing and multimedia mobile phone communications.

There are very many applications of basic wireless networking already in place in schools. For example approx. 21% of primary and 54% of secondary schools had some wireless networking in 2004 (Prior and Hall 2004). Many case studies have been made of the application of these in schools, for example, see Perry (2003a).

The perceived advantages and motivations are both practical and pedagogic. At a practical level for example, are the lower cost and levels of disruption of wireless networking installation. Pedagogic motivations include exploring the new mobile and collaborative working opportunities afforded by wireless laptops and palmtops/PDAs.

While the use of wireless networking is being widely explored in schools, the use of mobile phones is still a relatively unexplored and controversial area, with many schools banning the use of newer camera phones – see 'Disruption From Without' below.

Sentient Objects?

The ubiquity of wireless networks extends beyond telecommunications and computer devices for use by humans. By embedding wireless network technologies into every day objects they become an integral part of our wider electronic environment. They can respond to networked queries – 'device, where are you?' (useful if you have lost your keys) or if coupled with internal or external sensors, more complex queries – 'device tell me the temperature where you are?', or 'how many people have walked past you in the last 10mins?'. They can be programmed to respond to particular (potentially complex) situations – 'text me if…'. Rheingold (2002) calls these objects 'sentient' in the sense that they sense and respond to those sensations.

There are various systems that utilise these interactive objects, for example the Cooltown project (http://www.cooltown.com/cooltown/) in which personal devices can interact with *sentient objects* in the surrounding environment as well as across the Internet. This means that the system can provide users with contextual (located) information and services. See also the Mobile Bristol research project, in which the vision of the test-bed is "*to provide a digital canvas over the city onto which rich situated digital experiences can be painted and new commercial ventures can be explored*." (Mobile Bristol 2005)

Other examples of educational applications of *sentient objects* are limited, although there are a number of research projects underway. One exploratory example is the "Ambient Wood Project' (Rogers et al 2005) where a natural woodland environment is augmented with simple proximity sensing devices which can identify the proximity of a PDA device carried by students and present relevant information via the PDA screen and speakers (including sounds that represent processes that are invisible, or that happen at different times). The students also have sensing probes (for light and moisture); these data were stored along with GPS location information allowing for reflection of the patterns once back in the classroom.

At the Colston Symposium I gave a light-hearted example of the application of these technologies at conferences and in classrooms: delegates' badges might contain RFID (Radio Frequency IDentification) tags, that uniquely identify the delegate. The seats in the hall could use sensors to detect the badges; they might also detect the presence of a (switched on) mobile phone. Once a phone was detected, the chair could report the fact to the conference organisers, who could then contact the delegate and ask them to turn off their phone, by phoning the delegate. On a recent visit to Singapore I was shown the 'classroom of the future project' (MOE Singapore 2005) based at the National Institute of Education. There I found a system that closely mirrors the above example: the seats detect the student, and notifies the tutor, who can then wirelessly use classroom management software to view and take control of the student's tablet PC.

Wearable, Telepresence and Location Aware Computing

The concept of wearable computers is closely aligned with the original conception of ubiquitous computing. Networked computing devices become small enough that they can be 'worn' or carried 'unconsciously'. At a basic level it might be said that current devices such as mobile phones and wireless PDAs are a small step towards wearables. Wearables have a close synergy with another group of technologies that provide location awareness – that is, the ability for the device to 'know' where it is.

Location awareness can be implemented using a number of approaches, for example short range electronic beacons as used in Cooltown (see above), mobile phone cell locations (areas within the range of mobile phone aerials) or GPS (Global Positioning System) that can (in principle) pin a location down to about 5-10m. By using any of these it is possible to provide location aware services. Such services are now nearly universally available via mobile phone text messaging. Queries might be 'tell me where the nearest Indian restaurant is', or even 'tell me when I am near a person with similar interests or friends' (Socialight 2005). Rheingold (2002) points to many other examples of developments around the world where the mobile phone is finding applications far from its original supposed propose (to allow people to talk while away from their land lines).

Educational applications of such location awareness have been explored for some time within museums, galleries and other visitor attractions, with the potential to augment the visitor experience with additional information based on the particular exhibit that they are looking at. Original systems used local Infra Red (IR) or radio beacons (e.g. Heard et al 2000), more recently at for example, Tate Modern (Tate Modern 2003) use WiFi and wireless PDAs to provide context, and audience specific multimedia presentations, about the art work. Yet others use GPS where outdoor exhibitions are explored. For example the CAERUS project, in the context of a botanic garden (Naismith et al 2005)

An educational example that moves beyond providing information in context is the Virtual Savannah project based in Bristol, UK (Facer 2005 and Facer et al 2004). Here, school age children explore an area such as a school playing field which has superimposed upon it a virtual African Savannah. The virtual environment is 'perceived' using wireless PDA devices with GPS to enable the system to locate the pupil. The educational goals of the system were to help pupils gain personal experience and understanding of some of the issues involved in surviving as a pride of lions.

Yet more ambitious use of handheld devices to facilitate educational interactions date back to 1996. The Worldboard project (Spohrer 1999) was educationally motivated, and was based on using GPS data to allow the annotation of locations [worldwide] with electronic data (casual comments, scientific data, images, etc), by storing the annotations on a Web server, and making those available to users. The users might use wireless devices to 'read' the annotations in context, thereby reading, seeing or hearing the annotations of that location from others. The original ideas included providing visual overlays of geophysical data as well as more obvious textual or numeric data.

Another deeper integration of wearables into clothing is illustrated by examples of force feedback technologies. Using clothing (for example a glove) with actuators that simulate the pressure that would be felt by touching or holding an object in a virtual world. When this technology is combined with wireless networking it becomes possible to 'feel' and interact with real-world objects remotely. Such *telepresence* has very wide ranging implications and applications. The potential is demonstrated by the fact that for some time, it has been possible to conduct clinical telesurgery (remote surgery) over distances of 1000s of kilometres, (Marescaux et al 2001).

A recent example of an affective/social application of telepresence is the F+R Hugs (hug shirt) by a company CuteCircuit which "*… is a shirt that allows* [users] *to exchange the physical sensation of a hug over distance. Embedded in the shirt there are sensors that feel the strength of the touch, the skin warmth and the heartbeat rate of the sender and actuators that recreate the sensation of touch, warmth and emotion of the hug to the shirt of the distant loved one.*" (CuteCircuit 2005). The T-shirt uses a Bluetooth connection to a mobile phone and so is (in principle) usable anywhere a phone signal can be received. While this example does not obviously have direct educational application, it highlights the potential for affective applications of force-feedback and wearable technologies which are easily forgotten in technological applications.

Network Effects – Augmented Memory

By combining the devices described above with others that are widely available (for example, very small digital still and video cameras (HP Labs 2004), real-time physiological monitoring, accelerometers providing additional velocity and direction data, visual display screens integrated into spectacles and very large storage), very striking potentials arise. At WWW2004 Rick Rashid of Microsoft showed a video derived from this type of monitoring (Rashid 2004). Combining continuous data from all of these devices it is possible to in effect produce augmented memories – replayable, searchable and sharable.

Experiments in this kind of capture have been in progress for many years (Rheingold 2002 p106). An extreme example of the potential is from the USA where the Pentagon's so-called LifeLog project (Shachtman 2003) explores the possibility of gathering "*every conceivable element of a person's life, dump it all into a database, and spin[ing] the information into narrative threads that trace relationships, events and experiences.*" While this may be a limited view of 'a person's life', it does illustrate the scale of the potential.

This example also illustrates *a more general principle*. While individual technologies may of themselves be significant (offering new or enhanced functionality and capabilities), when they are combined or converge into single or networked devices, their potentials and impacts can be very much greater.

Future Technologies

All of the technologies described above are already under active development. There are many more that could have been listed, including robotics and immersive computer interfaces, 'digital paper', nanotechnology, distributed computing, machine readable semantics, ultra fast networking and storage technologies on a scale that are all but effectively limitless. It seems inevitable that the ubiquity and pervasiveness based on the vanishingly small and integrated network computers will come about.

Predicting the future of technological development is notoriously problematic – history is littered with examples of predictions that were very far from what actually happened. Indeed it can be strongly argued that the actual uses and impacts are often counter intuitive (Woolgar 2002). However it seems likely that over the next tens of years (not withstanding any potential catastrophes) we will develop very much more advanced computer technologies, built on traditional lines or using biological or quantum approaches, running applications that allow types of interaction what we cannot yet imagine, and using effective (if not human like) artificial intelligence, and as we have seen, becoming vanishingly small.

We are also likely to gain much more developed understanding of ourselves, through the study and practice of genetics, non-invasive scanning technologies, advances in psychology, etc. The outcomes of the combinations of these two areas of development alone will likely be striking. The rate of technological development shows no sign of slowing. Whether it is faster or slower it seems useful to look ahead at some of the potentials for education.

Ubiquity, Disruption and Education

The following two sections look at longer term potential technological disruption(s) in educational contexts from two directions: 1) within existing educational models and practices, where the affordances of ubiquitous technologies (i.e. the opportunities that are 'afforded' by them) offer ways of improving and/or disrupting the practice of teaching and learning in our existing contexts and 2) from without, where changes in the wider environment and context might disrupt the education system at various scales.

Disruption from Within – New Affordances and Pedagogies

The Colston Symposium

In the context of the Colston Symposium, the organising committee decided (in line with the more open definition of 'disruptive technologies') to highlight the potential nature of technological disruption in an educational context by using instant messaging and blogging technologies as an integral part of the symposium. Delegates had WiFi access to the venue's network as well as IRC and Blogging facilities linked to the event. This meant that online discussion and note taking could take place live during the symposium (Colston Symposium 2004). It was planned that both the IRC and blogging output would be visible during this author's presentation. While technical faults meant that was not possible, when these were corrected (near the end of the presentation) subsequent speakers and informal votes from the audience meant that the projections were available throughout the event (Jacobs and McFarlane this edition).

The experiment had limited success in some ways, for example in terms of the levels of participation by delegates. It none-the-less succeeded in illustrating how the affordances of even very basic pervasive technologies might disrupt traditional pedagogic practicesfor example "*Back-channel technologies empower members of the audience to communicate among themselves, and to investigate all kinds of related information and make these public. Decades of research in science studies have shown that scientific progress is embedded in social practices… which can be hidden when findings are merely announced from a stage…*" (Jacobs and McFarlane this edition).

In this particular case, the disruption arises largely because the technologies offered the potential of new forms of interaction between the key actors in the symposium context and also between the actors and their wider electronic environment, e.g. local networks and the Internet.

This is a good illustration of how new affordances provide new opportunities as well as potential disruptions and reassessment of traditional practices; since computer networks have been used in schools, network managers (including the author in the past) have been carefully disabling facilities that allow users of the network to send each other messages – a facility built into the majority of networking software since their inception. This was because the kinds of messages that tended to be sent were seen as not generally of an 'educational' nature. However, the advent of mainstream use of wireless networking and IRC and IM technologies outside of school settings; has challenged the assumptions on which the disabling of functionality is based.

Pedagogic Practices

At the symposium the use of simple text-based 'chat' technologies (see previous section) challenged traditional roles, assumptions and norms. Using carefully designed multimedia IM technologies, interactions can be easier and richer. They offer not just multimedia chat and file sharing, but also shared virtual whiteboards and shared control of computer programs, along with many other potentially valuable affordances. For example many academic communities and businesses use IRC and IM as a standard means of communication (e.g. via tools such as Jabber[1]). They often use these to respond to real-time queries or issues from colleagues or other members of their communities worldwide, as at my own workplace.

It might be possible that they (and their employers) would be willing to act as ad hoc or 'always on' online experts, on channels dedicated to school topics or individual schools. These ideas have been and are being explored successfully within 'safe' closed community environments such as Think.Com[2], where specific live events are organised or where queries are made via asynchronous bulletin boards or email. The always on/real-time (ubiquitous) implementation of this kind of use would, illustrate how they might open up and challenge existing pedagogic practices. For example moving from a single teacher responsible for the learning of their students, to a community of real and virtual 'teachers' or teacher/learners, (peers are just as likely to support each others learning), and adult members of a community learn from other adults and students.

This is a rich seam of potential disruption that combines the many affordances of mobility, under the heading 'mobile learning' (see for example the special edition of this Journal covering 'wireless and mobile technologies, vol 19. 2003). A very great deal of activity and exploration is taking place in this area. They challenge not only traditional pedagogic models of the use of technologies and the role of teachers (see for example Roschelle 2003) but also the nature of how we organise learning activities in space (why classrooms?) and time (why in time constrained slots of *x* minutes?).

Some projects have explored working outside of traditional models and constraints e.g. notschool.net at Ultralab (Notschool 2005), working with disaffected school students, highlight the potentials of stepping outside of those traditional structures. As do many projects that are experimenting with data collection using mobile devices and Wireless mobile sensors (Stanton et al 2005 and Rogers et al 2005) and Future-Lab's experiments using the synergies of electronic games and simulations approaches coupled with mobile technologies (Futurelab 2005b)

Draper and Brown (2004 p93) also demonstrate how even simple ubiquitous technologies such as electronic voting systems; where students use handsets to 'vote' on the answers to multiple choice questions (see also Roschelle 2003 p262), allows for more effective student-tutor interaction. Their use introduces potential for more 'contingent teaching' on the part of the tutor. That is, making the decision of what to teach next, dependent on the live feedback from students. This is an example of a technology enabling what might be regarded simply as 'good teaching' in a small group situation, in the normally far less interactive environment of the lecture theatre.

These projects and illustrations and many like them, are exploring the use of technologies that already exist and indeed are often many years old. They illustrate how the affordances of even

[1] http://www.jabber.com/
[2] http://www.think.com/

basic and only partially ‘ubiquitous’ technologies can enable the more effective ways of doing what is already seen as good pedagogic practice (voting system example). However they also provide new ways for learners to engage with concepts (Virtual Savannah example) and can simultaneously undermine traditional didactic pedagogies, while offering new potentials for learning involving peers and external people (instant messaging and other wireless networked conferencing technologies).

Even so, with our motivation to stimulate discussion, it might be argued that even now, mainstream implementation of *e-learning*, away from the relatively rare and innovative projects described above, is largely focused around the use of Virtual Learning Environments and data projectors (at a higher education level) and on specific applications of Web-based resources, interactive whiteboards and wireless networking (at school level). None of which constitute ‘new technologies’. We have not yet begun to touch or explore the potential implications of many existing technologies (for example location aware and ‘sentient’ objects) within educational contexts. Of course the implications and potentials spread far beyond the small number of issues raised in these few examples. For example the combinations of various pervasive technologies enable ubiquitous surveillance and monitoring of people and places – the educational affordances but perhaps more importantly ethical and moral issues in an educational context are as yet still largely unexplored.

Looking to the Future

I will end this section with an example from the more distant but still foreseeable future, where the affordances of the technologies might challenge (and undermine) the foundations of traditional education, not only with regard to the practice of education, but also to the basic assumptions on which our model of what it means to be human is based; augmented memory and telepresence described in the previous section.

It can be argued that our traditional education system has been founded on the assumption that humans are individuals – as discussed in the next section this is reflected most strikingly (even today) in our school exam and assessment systems. These have almost exclusively tested individuals as individuals, alone, unconnected to others and unable (in general) to use external sources of information.

Many argue (see for example Turkle 1995) that networked technologies change and challenge our traditional conception of our individual or group identities. It seems likely that more pervasive technologies such as those that enable augmented memory and telepresence will challenge these concepts more profoundly.

As argued by Shadbolt (2002), in a proposal for making the creation of an augmented memory system (Mnemonet) a ‘Grand Challenge of Computer Science’ (BCS 2005); to a large degree, “*We are our memories.* ” (See also Landsberg 2000)

The ability to re-experience personal multi-modal/sensory data (e.g. visual, auditory, touch and representations of physiological states such as heart rate), linked to additional information about our real and virtual environments at the time, seems likely to have a significant impact on our sense of self. Especially because many of these experiences would have naturally fallen out of our conscious memory. How much more significant then, would it be, to ‘recall’ others’ experiences?

Before exploring what this kind of augmented memory might mean for education or in educational contexts, let us return to the related ideas of telepresence.

The ultimate goal of telepresence researchers is the "*experience of being fully present at a live real world location remote from one's own physical location. Someone experiencing transparent telepresence would therefore be able to behave, and receive stimuli, as though at the remote site…*" (TTRG 2005). TTRG (2005b) argue that, "The ability of a pupil, student, or researcher to explore an otherwise inaccessible location is a very attractive proposition. For example locations where the passage of too many people is harming the immediate environment or the artefacts themselves, e.g. undersea exploration of coral reefs, ancient Egyptian tombs and more recent works of art."

If we combine these two groups of technologies the implications seem likely to be profound. At the level of new affordances, the concept of students being able to experience the sharable *multi-sensory* components of augmented memories of teachers, experts, practitioners in all forms of activity (e.g. brick layers, sports people and surgeons) , actors (e.g. re-enacting historical events) , peers, etc. is startling. These could be annotated (e.g. with narratives) by others, the students could annotate them themselves, or collect and combine different perspectives on the same event or situation.

It would be possible to author learning experiences that give students direct, concrete experience (e.g. visual, auditory, kinaesthetic and physiological) of real world situations from the perspectives of other people. Not only practical and intellectual but also emotional experiences might be explored (e.g. of the form '… and what did it look/feel like from their perspective?'). What might a teacher learn from 'watching' one of their own lessons from the perspective of a student?

Equally significant would be the ability to experience and importantly *interact* with real objects in places, situations and environments not previously accessible. Of course there is also the potential to experience and interact with virtual or synthetic real/virtual environments. The ability to gain direct experience real world examples of what might otherwise be quite literally unimaginable or to use virtual models that help understand otherwise abstract and/or de-contextualised concepts, (e.g. changing of physical constants in physical equations).

If the two technologies are combined directly it becomes possible to experience in *real-time* the 'augmented memory' experiences of someone else. To interact, ask questions, provide feedback (verbal, kinaesthetic, visual, etc.), perhaps even take or share control of the other person (e.g. as part of teaching physical skills). This many sound like science fiction, but there seems no technical reason why it will not be (or in fact is not already) possible.

As with the previous examples in this section, these new affordances and pedagogical potentials give rise to questions that challenge the nature of our educational practices and norms. For example what is the role of a teacher, or a learner, or a school, or a timetable, or a classroom, or a curriculum, if 'memories' can be replayed and borrowed at will? or when it is possible to 'be' in any room with any person (or group of people) real or virtual? We will return to these and other questions in the final section.

Disruption From Without

It is important not to lose sight of the fact that technological change is simply one facet of change in our wider society and these wider changes (moves towards an information/service based economy, globalisation, etc.) are impacting heavily on educational innovation at present. For example, the demand for workers that possess flexibility and the ability to quickly learn new skills, appears to be a requirement of the so called 'information' or 'knowledge' economies. These are reflected in part in an increasing focus on the underlying skills and aptitudes to support such flexibility and in initiatives such as including 'thinking skills' explicitly in the curriculum (DfES 2004b), focused on helping children learn how to learn.

School and Not School

A further pressure is illustrated by studies into access to ICT resources by children and young people. These have consistently demonstrated that, in many cases, there is a significant mismatch between access in and outside of school; recent studies as part of the Impact2 research project (Comber et al. 2002) and the Interactive project (Facer 2001) indicate that pupils often have access to more, more diverse and more powerful, hardware and software at home than at school. Those more adept and avid users of the various communication possibilities may find it somewhat frustrating that this central part of their everyday lives cannot come into school. A quintessential instance of this is related by Prensky (2001) who tells of a pupil's frustration at being made to 'power down' when they enter school, leaving their mobiles, computing and games machines behind. It is unlikely that this disparity will lessen; economic sustainability of ICT infrastructure within education is a major concern, as noted in the Impact2 study (Harrison et al 2003) "*Sustainability and improvement of ICT provision are key issues. As many pupils have access to superior hardware and software at home, there are concerns that demand for ICT provision is outstripping what schools can afford to supply. Additionally, shortages of space, funding and technical expertise are key factors restricting schools' ability to maintain and develop suitable systems.*"

Prensky's view, that we now have generations divided, between 'digital natives' brought up immersed in communications and computer technologies, and previous generations seen as 'digital immigrants', does not hold as a generalisation - see for example Facer (2001) who demonstrates that the 'native' stereotype is unrepresentative of many young people. However it is equally clear that there are differences in the levels of desire and/or comfort with integration of technological usage into every day activities (Facer 2001 and Livingstone 2002). These differences are layered on top of the more traditional issues of digital divide focused around access – simply swapping wholesale from paper to computer based approaches, or chalk and talk, to real-time computer mediated peer to peer interactions, would seem likely to be no less divisive than the traditional digital divide.

This complex set of issues extends outside purely educational issues, for example there are good reasons why camera and video phones might be banned from schools (BBC News 2004), e.g. using a phone camera it is possible to capture images secretly and if combined with web publishing technologies it is possible to publish (or share) images from school instantly on the Web. Another recent example is 'happy slapping' in which bullies film their fights (Shaw 2005). The child protection issues are striking.

Curriculum, Assessment and Literacy?

These examples are also interesting illustrations of a yet wider set of issues. Firstly once again they are examples of how the uses to which technologies are put are often *far* from those originally foreseen, envisaged or sometimes desired (Woolgar 2002). Secondly one might argue that it is not only in school that such situations arise – and perhaps it is in school where the risks, rights and responsibilities should be explored and debated. They stand alongside the many issues of identity, privacy, personal safety and trust etc. in our increasingly synthetic (real/virtual) world. These and many other external 'disruptions', due in part to the introduction of more ubiquitous technologies, are already driving changes and debates in the role, curriculum and practice of teaching and learning as well as educational policy.

Let us look at the case of assessment: in a world where access to 'information' is ubiquitous to the point where no professional would be without the standard information tools of their trade; where our communications channels to others are 'always on' and ubiquitously available (Agre 2001). It seems somewhat unrealistic in preparing children for the 'real world', to expect them to answer questions without access to the kinds of information tools appropriate for the practices of those subjects in the adult work environment, and to write *all* examination questions by hand. These and other issues have lead to recent developments in e-assessment that seem likely to disrupt existing practices beyond assessment as Ridgeway et al put it (2004) assert "*E-assessment is a stimulus for rethinking the whole curriculum, as well as all current assessment systems*."

Literacy is another example: ubiquitous access to *new media*, Internet and associated network communications, pervasive 'carry aroundable', if not wearable, technologies, has been raising issues of the meanings of fundamental pedagogic concepts such as 'literacy' for many years (Kress 2003 and Livingstone 2002, chapter 6). As Livingstone argues (Livingstone 2002 p224) with respect to shifts in conceptions of literacy, "*While it seems clear that young people welcome this shift* [from narrative to display], *it is less obvious that the education system is prepared to accommodate it as yet, still tempted to contrast media (i.e. books and screen), rather than conceiving of the shift from one model of literacy to another*." The implications of the new interactive multimodal devices under development, for example as part of the 'augmented memory' technologies described above, will undoubtedly challenge these conceptions further.

Once again these illustrations are taken from technologies that are already widely available and in use. If we return to the more future looking examples of augmented memory and telepresence from the previous section, our questions in this context might be, 'how might the world change if/when such technologies become widespread?' and 'what implications might those changes have for the nature of and practice of education?'.

Reflections and Questions

At the Colston Symposium 2004 the presentation (on which this paper is based), introduced the technologies and contexts outlined above. It ended with questions that acted as the basis for discussions in the breakout groups for delegates.

Even in the year since that presentation, the technologies, their functionalities/affordances and applications have moved on. At the same time, research reports on the potential educational use of many existing technologies, such as mobile phone/PDA/computers are published on a weekly or even daily basis.

The most recent of these has arrived as I write this paper (7 May 2005), 'Mobile technologies and learning: A technology update and m-learning project summary' (Attewell 2005). The back cover begins, "*The use of mobile technologies to support, enhance and improve access to learning is a relatively new idea and while many teenagers and twenty-somethings are expert mobile phone users many educators are not*."

This quote reflects the underlying issues raised by the questions at the end of my Colston Symposium presentation. With very few exceptions, practicing educationalists are not actively involved in the development of these technologies nor are they active early adopters of new technologies. And so they are in a difficult position to answer questions such as "Does the role of 'education' change in a totally networked world? If so how?" or "What are the implications for educational assessment in an *always on*, *constant touch*, *instant information* environment?".

Without personal experience of the, often unexpected, affordances of these ubiquitously connected devices, it is difficult to see how educationalists can begin to make meaningful assessments of how newly evolving technologies might enable more effective educational opportunities nor how educational practices/structures/assumptions might need to change to respond to changes in society – especially those that impact on the lives of their students.

This effect is compounded by the shortening of innovation cycles (for technologies, products and services), e.g. it is hard to remember that the now ubiquitous high capacity MP3 player has only been in the mainstream market since 2001 (Van Buskirk 2005).

To date, the development of firm foundations for guidelines, best practices and policy development, have relied on traditional educational research approaches. These involve academically rigorous long term, controlled studies (for example the Impact study of ICT in schools - Watson 1993). However if development cycles are of the order of a year or less, such approaches become impractical as means to evaluate the educational potential of technologies. This is because in many cases even before the findings are published, the affordances of the technologies and, as importantly, the contexts in which they are used, will have changed.

The situation is compounded by the traditional publication models of research papers with lead times often of the order of many months and further yet by (necessarily?) bureaucratic processes to move from guidelines to policy development, to authorising resources [and the costs can be very high] and finally to actual practice in schools. Action research (Mills 2002) approaches provide one means to overcome this issue. However understanding how policy development and funding models can respond quickly - where no rigorous research findings are available (or even possible) - is an outstanding issue. This is particularly the case in what are largely highly centralised education systems in the UK.

The Innovator's Dilemma Revisited

This paper began with a description of 'disruptive technologies' from The Innovator's Dilemma – a book whose focus was to explain how organizations could respond to and indeed foster their own disruptive technologies. This perceived need is clear in a business context. Companies that do not respond effectively to disruptive technologies in their own business sector may find that their own products or services are displaced by the newer technologies as they, often very rapidly, mature.

In the interests of stimulating discussion, it might be useful to revisit Christensen's characterisation of sustaining and disruptive technologies is interesting in an educational context. For example: sustaining technologies "*foster improved product performance.*", and "*can be discontinuous or radical in character, but they serve to improve the performance of established products along the dimensions of performance that mainstream customers have historically valued.*" (Christensen 1997 p xviii)

In contrast disruptive technologies;

1. "… usually result in *worse* [original emphasis] performance, at least in the near term", [as measured by metrics of mainstream market].
2. "… bring a different value proposition to the market than had been available previously."
3. "… have other features that a few fringe customers value."
4. "… [a] firms' most profitable customers generally don't want, and indeed can't use products based on disruptive technologies."

Substitute 'educational' for 'product' and 'educational practices' for 'products', in the descriptions of sustaining technologies and it would read very naturally.

If read from an educational context, the characteristics of disruptive technologies are also interesting. It is not likely that innovations that would *probably* bring 'worse' results (albeit only in the short term) would be introduced into an educational system. Indeed it would be morally difficult to justify to doing so. However projects like NotSchool (see above) and the work reported by Attewell (2005) on the use of mobile technologies with '*young adults with literacy and/or numeracy difficulties*' might be seen as reflecting different *value propositions* and *fringe markets*. And as with disruptive technologies, it is very likely the findings from these activities will feed into mainstream practices. Finally the issues made in the previous section about assessment practices and literacies, mirror the last point about the expectations of dominant customers.

If we wish to foster the innovative and potentially disruptive uses of ubiquitous and pervasive technologies in educational contexts, then Christensen's model also provides some interesting advice. In order for large successful companies to overcome the dilemma – that "*logical, competent decisions of management that are critical to the success of their* [market leading] *companies are also the reasons why they lose their positions of* [market*] leadership* [in the face of potentially disruptive technologies]"

He argues that such companies need to protect those within their company exploring potentially disruptive technologies from the traditional expectations, norms, economic restrictions, business rules etc. of the larger company. One might look at education through the same model. The traditional practices of mainstream education is of their nature restrictive, in particular the National Curriculum in England and Wales, producing what might be provocatively described as a near monoculture of practice; with innovation away from the norm very effectively discouraged by related metrics and regulations. In order to identify potential 'step changes' or enhancements, afforded by new technologies, to the practices of learning and teaching it is necessary to conduct appropriate experimentation. In such restrictive environments the radical changes to practices, structures and regulations necessary to enable appropriate experimentation are unlikely to be made.

As an aside it is interesting to remember that the 1988 Education Reform Act that bought in the National Curriculum included the clause: "*For the purpose of enabling development work or experiments to be carried out, the Secretary of State may direct as respects a particular maintained school that, for such period as may be specified in the direction, the provisions of the National Curriculum— (a) shall not apply; or (b) shall apply with such modifications as may be so specified.* (HMSO 1988), explicitly to enable such experimentation. A similar clause appears in the 2002 Act. To the author's knowledge no school ever successfully used this clause (an enquiry to the DfES to clarify this point has not been answered at the time of writing), nor in the author's experience are many educators aware the clause exists. Initiatives such as Education

Action Zones (DfES 2005) have been given the explicit option of disallowing the curriculum in special cases and Academies (DfES 2004) are explicitly been excluded from having to apply the National Curriculum, again to enable such experimentation. However key stage assessments and OFSTED inspection criteria have still applied.

The examples of research projects described above represent what might be thought of as traditional approaches to a kind of protection from mainstream educational metrics. They sit outside the formal education system and so are not accountable under its direct measures of success – indeed they are generally measured explicitly for their innovative and cutting edge nature.

However it can be argued that such contextual distance and innovation focused targets, come with built in disadvantages. Firstly the abstraction away from the 'real world' of classrooms, class sizes, targets and metrics makes direct transfer to the school context difficult. Secondly it is often the case that funding is available for innovation, cutting edge research and feasibility studies but little, if any, is available for moving from 'research' to deployment.

This effect might seen as being amplified by the metrics used to assess the research community itself. The Research Assessment Exercise's (RAE), definition of research states that it is "*… original investigation undertaken in order to gain knowledge and understanding.*" (RAE2008 2005). This often precludes 'development' activity that moves from a proof of concept study or initial research (where the new knowledge *has already* been generated) to deploying a pilot or fully fledged systems.

Perhaps the best example in the UK of Christensen's notion of protection is NESTA Futurelab (Futurelab 2005) based in Bristol, funded by the UK Lottery Nesta (National Endowment for Science Technology and Arts) fund. It was launched in 2001: "*NESTA Futurelab is about turning ideas into prototypes. By linking creative talent, educational expertise and the power of digital technology, we are pioneering ways of using ICT to enrich and transform the learning experience for people of all ages and abilities. As a blue-skies research facility and creative incubator, NESTA Futurelab provides research and development support to those with new ideas for compelling interactive learning resources… We have strong links with schools and learning centres across the UK, providing direct access to learners and supporting the inclusion of children as co-designers in projects …*"

Futurelab, like other research projects, sits outside of the formal education system and so is not accountable to its measures but nor has it been *directly* measured by those of the traditional academic research community. It also has a lifetime and set of objectives beyond a single research project. This has enabled it to organise conferences and commission wide-ranging literature reviews. Its very practically focused perspective has a longer term view, often missing from such projects: "*Futurelab invites ideas that are innovative, creative and forward-looking. We are particularly looking for projects that make use of technologies likely to become widely available in 5-10 years' time including broadband, wireless devices, artificial intelligence and pervasive technologies.*" (NESTA 2005)

FutureLab and similar projects such as NotSchool, that experiment with the applications of potentially disruptive technologies in an educational context, while remaining outside of the restrictions of mainstream educational practice and regulation, seem like good and effective examples of enabling the exploration of the potentials (positive and negative) of potentially disruptive technologies. It will be interesting to see how these experiments and explorations move to deployed applications in widespread or mainstream educational settings.

Conclusion

In the interests of stimulating discussion – the goal of the original Colston Symposium - this paper has deliberately taken a very techno-centric and uncritical perspective on the introduction of ubiquitous and pervasive technologies into education. However there is a vital role for critical perspectives. The penultimate questions from the Colston Presentation were "*Should educationalists be playing a more active role in the development evolution of these technologies/* [and related] *regulations and standards? Are there technologies and uses of these technologies that educationalists should lobby against?"*. These are real and urgent questions for educationalists. There is no likely benefit to be had from uncritical acceptance of new technologies. This is especially the case as (and if) traditional research approaches to evaluation become inadequate in the face of the rapidity of technological developments.

These technologies will and are causing change and disruption to traditional educational practices. Informed and critical perspectives such as those argued for by Woolgar (1999) seem to be a vital part in the determination of how such disruption is dealt with. Ultimately however it seems likely that we need to develop a strategy for dealing with, understanding and utilising disruptive technologies on an ongoing co-evolutionary basis. A strategy for developing strategies as it were.

This need for continual (and apparently, increasingly rapid) co-evolution of technology, culture, theory, policy and practice, can and often does, feel daunting – and given the responsibilities and issues involved, inevitable. Some years ago I came across a Buddhist concept that sums up this state of affairs, but also challenges any unthinking drive for change: 'Apratistha' literally 'to settle down where there is no settling down.' (Mountain 1982). Embedded within the concept is an acceptance that there is no stable state of peace or rest - or in our case, *right* education policy or practice. It is not a matter of 'find the right answer and all will be well forever'. Perhaps this can be translated [poorly] as a challenge - to find a way to understand and practice education, in a way that is able to adapt intelligently, compassionately and wisely to continual change.

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