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BEYOND THE HORSELESS CARRIAGE:

Harnessing the potential of ICT in education and training

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Introduction

> *It has been observed many times that a new technology evolves in two stages. In the first stage it evolves previous practice. Early automobiles were known explicitly as horseless carriages, and only later did we get motor coaches, transports and interstate highways.*
>
> Stephen Downes, The Buntine Oration 2004

While Information and Communications Technologies (ICT) have greatly transformed the practice of business, manufacturing, administration, finance and the provision of other services, ICT has yet to impact on the delivery of education and training in a similar way.

The slow rate of take-up and utilisation in education and training would appear to be puzzling, especially as education and training focusses on information, discourse and developing knowledge which ICT enables and enhances. As Rosabeth Moss Kanter cited in Hargreaves (2003) states:

> The revolution that will shape the next century is on the transport of ideas and information … at the heart of the communications revolution lies something that will benefit humanity: global diffusion of knowledge. Information once available only to the few will be available to the many, instantly and inexpensively (Hargeaves, p3; Kanter, 1983).

Yet more than 20 years after Kanter's predictions and a revolution in personal and business computing, resistance to change prevails in the integration of ICT in the delivery of education and training services within our school, vocational college and university systems and institutions.

This paper seeks to reflect on the reasons for this inertia by examining the evolution of ICT in education and training, the opportunities that ICT brings and looks beyond current theories of learning to enable readers to envision the harnessing of the full potential of ICT, within education and training.

Background

Since the early days, in the mid 1970s, of mass produced personal computers, ICT has now reached a stage of maturity, robustness and a zero cost potential. The widespread and increasing take-up of the use of computers in business, industry, government and at home has been well documented.

The most recent statistics, in March 2005, published by AC Nielsen/NetRatings for Australia indicate 66.2% of the population are Internet users (Internet World Stats, 2005).

Although this figure does not indicate the number of connections to households, it does indicate a strong take-up of connectedness to the Internet. The Australian Bureau of Statistics (ABS), in 2004, reported that the number of new broadband connections to the Internet is increasing at a faster rate than new dial-up connections (ABS, 8153.0 *Internet Activity*, 2004).

The slow rate of take-up in education and training, in the light of this national connectedness to the Internet, reflective of similar trends in the USA, remains surprising.

Rod Paige, Secretary of Education in the USA, stated recently:

> Education is the only business still debating the usefulness of technology. Schools remain unchanged for the most part, despite numerous reforms and increased investments in computers and networks (US Dept of Education, p22, 2004).

The use of ICT in education and training enables educators to achieve some educational goals more quickly, with less effort and beyond class and lecture rooms. One such example is the capacity to develop personalised learning programs, so that students can learn at their own pace, in their own learning style and possibly in their own time.

However, even though new opportunities are possible, educators and trainers continue to apply ICT within traditional educational environments. As Rod Paige stated in a letter to the US Congress:

> Too often, schools simply applied technology to existing ways of teaching and learning, with marginal results in student achievement (US Dept of Education, p4, 2004).

In Australia, the Australian Council of Deans of Education (ACDE) has recognised the necessity and urgency of preparing teachers to use technology and networking by arguing in their *New Teaching, New Learning: A Vision for Australian Education*, Proposition 7, that 'Technology will become central to all learning'. The Deans further argue that:

> Technologies of digitisation have the potential to transform learning relationships for the better, but this potential needs to be harnessed (ACDE, p1, 2004).

So then, what is the problem?

Again Rod Paige, USA Education Secretary states:

> The problem is … lack of adequate training and lack of understanding of how computers can be used to enrich the learning experience (US Dept of Education, p22, 2004).

Education can be transformed using ICT which brings new capabilities and capacities to learning. However, others would argue that ICT is but one factor, although critically significant and powerful in transforming schools.

Bosco (2004) argues that the promise of ICT will only be realised when changes in four key areas can occur: curriculum, pedagogy, organisational structure and technology itself. He further contends that curriculum integration is the key to effective use of ICT not achievement.

> The issue of whether computers and other allied technologies yield increased student achievement is secondary. The primary issue is the validity of the curriculum itself. Improving the effectiveness of instruction on content that is irrelevant, antiquated, or trivial is hardly a commendable goal. Thus, curriculum – what to teach – takes precedence over pedagogy – how to teach it. When the curriculum as it currently stands is accepted as a given, school reform is stillborn (Bosco, p7, 2004).

Bosco goes on to argue that the literary tradition, especially the technology of the book, and the way that we think about creating knowledge using books could be an impediment to the take-up and use of technology.

The technology of the book is linear which has a strong influence on how we think about the nature of knowledge, whereas information technology has enabled a rapid expansion of knowledge. The computer screen and the Internet, says Bosco, are replacing the book and the library, in relation to where and how knowledge is stored.

The technology of the book, in disseminating knowledge, has obscured the disorderly process of developing knowledge, according to Bosco. Whereas information technology is closer to the way that knowledge is created.

> Knowledge becomes a network of concepts with many connective pathways with more recognition of the dynamism and non-linearity of knowledge. The electronic tradition, like the oral tradition, is much more congenial to a communal approach to the construction of knowledge than the print tradition (Bosco, p10, 2004).

There are five messages at play which have implications for technology utilisation in the education and training sectors:

- a lack of take-up of ICT in education and training even though using ICT is prolific elsewhere, and
- new capabilities and capacities that can be realised using ICT

… and the need to:

- understand the connected nature and use of technology in shaping learning experiences
- overcome the restrictions of the print tradition in constructing knowledge, and
- adopt a communal and shared approach to the construction of knowledge.

Given the above, and the opportunities that ICT can enable in education and training, this paper argues that a new theory of learning, to provide a pedagogical framework for the digital age which is based on connectedness, is required urgently.

In order to develop new ways of learning within such a framework, educators must understand what is happening as education and training is transformed by the use of ICT.

The stages of ICT evolution and theories of learning

A number of theories about computers and ICT use in education have been proposed since 1975. Some of these theories are discussed below. Each theory can be argued to have reflected on the organisation of how the technology had been structured for its time. This section summarises the evolution of ICT in education, as a reminder of the pathway leading to the current state of play in ICT and introduces two major theories that have emerged along the way: Taylor's theory (1982) for the use of stand alone computers and Rushby's four network computing paradigms (1984). It concludes with a discussion about 'blended' learning and finally, Siemens' current theory of *Connectivism*.

Standalone personal computers in learning

One of the first standalone personal computers, the Altair was released to consumers in 1975 in the US. The Altair cost $439 for a kit and $621 assembled. Then in 1979, Apple produced the first highly successful mass-produced personal computer, the Apple II. In 1981, IBM sold the first personal computer using a disk operating system known as DOS.

Until the mid-1980s personal computers were used as standalone machines and mainly by enthusiasts, both, within education and broadly in society. However, the time would come quickly when mainframe users, especially in universities, would move to networked personal computers.

Taylor (1982), cited in White (1987), proposed a theory of use for standalone computers in education as a 'tutor', a 'tool' and a 'tutee'.

> When the computer acts as a tutor, the applications can be expected to be of the drill and practice type, based on rote learning principles, where the computer teaches the student. The computer as a tool can be thought of as an implement to assist the student to perform exercises, for example, writing, calculating, retrieving information, and so on (White, p15, 1987).

The computer as a 'tutee' is where the student is able to use a programming language, such as *LOGO*, to instruct the computer to perform certain tasks.

This theory was useful in considering standalone usage of personal computers but it only took into account computer usage in learning by individuals and did not account for networking opportunities.

Networked computers in learning

Networked computers have been in existence for over 35 years. The precursor to the Internet, ARPANET, was a large wide-area network created by the United States Defence Advanced Research Project Agency (ARPA). Established in 1969, ARPANET served as a test bed for new networking technologies, linking many universities and research centres. The first two nodes that formed the ARPANET were UCLA[1] and the Stanford Research Institute, followed shortly thereafter by the University of Utah.

However, the networking of personal computers did not become feasible until the late 1980s. Even though universities were networking nationally in 1982, they used mainframes and mini-computers which were not thought of as the Internet. Although personal computers were still in the ascendancy, Atari, a personal computer maker developed one of the first local area network systems of personal computers with the Atari 600XL in 1984.

Now for the first time people outside universities began to talk about sharing files, especially graphics and word documents, via a local area network. These local area network activities were usually confined to one room which lead to the implementation of laboratories of computers in both primary and secondary schools, and universities. Training institutions used standalone computers for administration, trade skills and business training, and only introduce networked computers when the Web was launched in 1989.

A theory which emerged from the UK to explain the use of networked computers in education was proposed by Rushby (1984), cited in White (1987). Rushby proposed four paradigms: instructional, revelatory, conjectural and emancipatory.

> The instructional paradigm is where the student learns from the computer whereas, the revelatory paradigm is where the computer gradually reveals information to the student, to close the gap between existing knowledge and that of the learner to master a concept, for example, simulation exercises or information retrieval activities. The conjectural paradigm refers to those uses where students can test ideas, such as modelling and artificial intelligence programs; and the emancipatory paradigm concerns the use of the computer to reduce the workload of the student (Rushby cited in White, p15, 1987).

This theory emerged from applications, used in universities at that time, which included simulations, networked printing and networked storage of files. This theory was widely accepted at the time, building on Taylor's theory of the computer as a 'tool', 'tutee' and 'tutor'.

The battle for networking protocols saw the TCP\IP networking protocol become more popular than the UK Coloured Book System, which had preceded it, due to Microsoft and IBM who distributed TCP/IP with each personal computer in 1995. Now there was an agreed international protocol for transferring files. The emergence of the web as an identification layer was pioneered by Tim Berners-

[1] University of California, Los Angeles

Lee and Robert Cailliau at CERN, in Switzerland, in 1989. Berners-Lee and Cailliau developed a uniform resource locator (URL) which operated over TCP/IP giving addresses to resources rendering them easily discoverable.

In 1992, Mark Andreessen a student at the NCSA[2]developed an application called Mosaic (the first GUI[3] browser) which transferred files across a range of different operating systems (Unix, MS DOS, MacOS), using the Internet. This was a major breakthrough and combined with TCP/IP and URL allowed the possibility of an easy to use intuitive graphical user interface.

Blended learning

The rise of networking and easy access to the Internet triggered debates among educational theorists about traditional teaching and teaching using computers. The term 'blended' learning emerged to describe a hybrid usage of computers and face-to-face instruction in traditional learning.

The theories of Taylor and Rushby, together with the concept of 'blended' learning, sought to meld the best of both worlds: traditional teaching and learning using computers with the Internet. However, they were somewhat short-sighted as theories because they did not consider learning beyond the confines of the classroom or lecture room.

Connectivism

As the World Wide Web developed further from its simple interface of websites, its possible uses were integrated with large scale enterprise architectures enabling the development of robust, secure web based services. Today, large companies are moving to global web based services which enable economies of scale not previously possible.

The maturing of the World Wide Web has enabled web based services that are globally accessible and integrated with desktop computing and has given rise to a new learning theory proposed by George Siemens called *Connectivism: A learning theory for the digital age* (Siemens, 2004).

Behaviourism, cognitivism, and constructivism as learning theories, distinct from theories about the use of computers in education, continue to be dominant in an age when the use of computers and the World Wide Web have revolutionised learning.

Siemens (2004) suggests that these learning theories are not in step with the environment within which learners engage today. His proposal attempts to merge accepted theories of learning with the digital age into a new understanding. For Siemens:

> Behaviourism, cognitivism and constructivism are the three broad learning theories most often utilized in the creation of instructional environments. These theories, however, were developed in a time when learning was not impacted through technology. Over the last twenty years, technology has reorganized how we live, how we communicate, and how we learn. Learning needs and theories that describe learning principles and processes, should be reflective of underlying social environments (George Siemens, p 2, 2004).

According to Siemens, behaviourism, cognitivism and constructivism focus on learning that occurs 'inside a person' and fail to address learning that occurs 'outside of people' and also how learning happens within organisations. Siemens argues that the inclusion of technology and connection-making as learning activities begins to move learning theories into a digital age. That is, using constructivism in a connected environment leads to new thinking about learning which Siemens calls *Connectivism*.

[2] NCSA is the US National Center for Supercomputing Applications
[3] GUI is Graphical User Interface

Siemens puts forward eight principles of *Connectivism* which are:

- Learning and knowledge rests in diversity of opinions
- Learning is a process of connecting specialized nodes of information sources
- Learning may reside in non-human appliances
- Capacity to know more is more critical than what is currently known
- Nurturing and maintaining connections is needed to facilitate continual learning
- Ability to see connections between fields, ideas, and concepts is a core skill
- Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities, and
- Decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision (Siemens, p4, 2004).

Developing knowledge which is current is an act of being connected. Knowledge today is neither static nor sequential reflecting print technology. Personal knowledge can be connected to a network which in turn can feed back into organisations and institutions, which in turn can go back into the network, and continue to provide dynamic information and engaging learning experiences to the individual.

Other writers, such as John Seely Brown (2002, cited in Siemens, p5, 2004) reflect aspects of *Connectivism*. Brown has argued for almost a decade that the Internet leverages the small efforts of many with the large efforts of a few. Rushby has talked about the emancipatory paradigm reducing the students' load and Bosco (2004) talks about learning as part of a community which reflects the non-sequential, iterative development of knowledge.

Summary

The period from circa 1981 to the present has seen the educational use of computers evolve from standalones, in laboratories, as networks, accessing the web and having a web presence, using the web and web services to nowadays being able to provide integrated web services for teaching and learning activities, resource collections, student records, administration, professional development and community relations.

The above brief overview of the evolution of ICT and development of a unifying theory, as proposed by George Siemens, can act as a guide to thinking about the types of learning activities in which learners can fruitfully utilise ICT. This raises the opportunity to explore the potential use of ICT as an enabler of learning activities in a connected world.

Opportunities from three international perspectives

ICT enables opportunities for teaching and learning activities not possible with print technology and a sequential construction of knowledge. Three recent papers illustrate what those opportunities could be. These papers have been published by DfES[4] in the UK, DEST[5] in Australia and Pennsylvania State University in the USA.

[4] DfES is the UK Department for Education and Skills
[5] DEST is the Australian Department of Education Science and Training

A UK perspective: opportunities for transforming education

DfES in its 2002 document *Transforming the Way We Learn* suggests that ICT enabled learning provides new opportunities to:

- '**access digital teaching and learning resources at home and at school**' - an issue that relates to wide community access to resources for learners
- '**simplify the administration of learning**' - a comment on managed learning environments
- '**modernise and remodel the teaching profession**' - which acknowledges the central role of teachers but is a comment on new skills required to make the most of the digital systems
- '**develop and gain recognition for skills**' - a comment on the place of ICT in the curriculum and the need to develop ICT pedagogy alongside the changing curriculum
- '**raise standards through innovation**' - which focusses on leadership and suggests that where ICT is used effectively then learners are advantaged and performing above targets
- '**promote and develop their school**' - points to the obvious benefit of being connected to the local community more effectively than in the past (DfES, p14-21, 2002).

These broad ranging opportunities indicate ways in which school learning can be transformed taking into account equity, community and learner participation in the life of a school.

An Australian perspective: opportunities for effectiveness

In 2004, a national study undertaken by Geoff Spring on behalf of DEST identified five modes where ICT provides substantial gains in effectiveness, including quality and cost benefits:

- **Classroom interactive learning** between students and teachers and among students
- **Independent learning** where students or teachers are learning and studying alone in a variety of environments and modes including aspects of self directed lifelong learning
- **Networked learning** through contact with groups, individuals and sources where quite different influences and experiences are creating a qualitative difference to both standard and blended teaching and learning
- **Organisational learning** including learning communities, learning precincts and learning cities
- **Managed learning** where education technology is creating, through computer managed communication and learning management systems, capability to enable students to negotiate and provide individualised curricula and learning experiences for each student (DEST, 2004).

These modes indicate a framework within which the use of ICT in education and training can be conceived and planned.

A USA perspective: opportunities for a new rationale

Finally, the work of David Jonassen (1994), then at Pennsylvania State University, focusses on developing a rationale for using technology. He argues that learners cannot use the tools without thinking deeply about the content and that the tools will facilitate the learning process. Jonassen presents a number of reasons why using technology as cognitive tools rather than conveyors represents a better use of technology including:

- Designers as learners
- Learners as designers
- Learners as thinkers
- Knowledge construction, not reproduction
- Reflective thinking
- Learning with technology
- Intelligent tools
- Distributed cognitive processing.

In the words of Jonassen (1994):

> Cognitive tools can be thought of as a set of tools that learners need in order to serve cognitive apprenticeships. They scaffold the all-important processes of articulation and reflection, which are the foundations of knowledge construction (Jonassen, p 6, 1994).

Jonassen introduces the concept of learners working with 'mind tools' which is congruent with developing new ways of thinking, a new and very powerful but possibly threatening concept to education and training.

Summary

Some common themes emerging from these three international perspectives, that support the unifying theory being articulated for the first time in Siemens' *Connectivism*, would appear to be:

- new ways of learning
- construction of knowledge
- communities of practice
- distributed access to resources, and
- networks of learning.

The above perspectives suggest the need for new ways of thinking about pedagogy in an ICT enabled world.

Research

A brief discussion about the pedagogical benefits of ICT in education and the need for a unifying theory of learning based on connectedness would not be complete without some understanding of research in the area.

Research into education and learning, especially in traditional educational environments has been abundant in the latter half of the last century. However, research into the effective uses of ICT in education and learning has been disappointing.

David Hargreaves (2003), at the *International Research Symposium* in Washington, argued that researching educational uses of ICT in traditional environments, and using tools and measurements associated with traditional education does not make sense. Hargreaves proposes that education is being transformed through the use of ICT and traditional measures are inappropriate. He suggests that 'research and development' should become 'development and research' to enable authentic reflection on various attempts to integrate ICT with education to enable improved learning, align educational environments to the environment of today's learners and enable different learning opportunities.

A brief scan of the available research into uses of ICT in education supports Hargreaves views. As evidence, two research reviews are cited here. Firstly, *A Systemic Review of the Effective Uses and Efficiency of Networked ICT in Education* prepared for the Canadian Council of Ministers of Education and Industry Canada, points to:

> … student satisfaction or preference for traditional instruction which does not seem to correlate to actual performance. Students appear to perceive networked instruction less favourably than traditional instruction regardless of their test scores (Charles Ungerleider, p41, 2003).

A reasonable argument, reflecting on this conclusion, would be that the potential and use of ICT is not effectively understood by educators.

A second and more significant study undertaken by BECTa (2004) in the UK, reporting to DfES, examines a number of ways to utilise ICT with curriculum and teaching practices. This study concludes that although there have been gains in the number of innovative and experienced teachers able to use specific ICT resources to improve student attainment, generally:

> Teachers need to understand the relationship between a range of ICT resources and the detailed concepts, processes and skills in their subject

and

> … teachers need to know how to integrate ICT into their pedagogical practices to complement the other teaching and learning activities and improve students' attainment (Cox, Webb, et al, p96, 2004).

The evidence emerging from practical observations of the implementation of learning resources developed by The Le@rning Federation (TLF) are much more illustrative of the advantages of ICT in education than the meta-analyses cited above.

> They [teachers] acknowledged the instructional design elements embedded in the learning objects: interactivity, scaffolded cognitive support, self-paced learning and immediate feedback assist student learning (TLF, p34, 2004).

The work of TLF is an illustration of development and research which would appear to be more beneficial in understanding the effective uses of ICT in education than traditional research.

Conclusion

This paper has addressed the differences between developing knowledge in an environment increasingly shaped by uses of ICT which reflect chaos, connectedness and communities globally as opposed to developing knowledge based on the limitations of the sequential nature of print technology. In an ICT world, knowledge is created more rapidly and more diversely, it is less predictable and reflects more of the oral tradition than print technology. Education will be required to change to accommodate this new creation of knowledge and ICT is one of the key enablers in this transition.

While this paper acknowledges that curriculum reform remains a major imperative for the transformation of learning using ICT, a first step in understanding the use of ICT in education is acceptance and exploitation of a unifying learning theory and pedagogical uses of ICT in learning, that is, technology enabled learning. Coupled with this is George Siemens' compelling theory of *Connectivism*.

Research has not been particularly useful in guiding discussion on transformational change to education. However, reflection on the development and experimentation with ICT in education and training does provide some indicators and guidance on beneficial pedagogical practices.

As suggested in Stephen Downes' 'horseless carriage' analogy, the use of ICT in education and training has only begun as access to ICT services and higher bandwidths become more available to learners. The danger is that we ascribe to new technologies the characteristics of previous media and accompanying educational practices without development and reflection on new and better ways to support and evaluate learning outcomes.

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