The Role of ICT in Teaching and Learning: 
Past, Present and Future Perfect

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You are invited to come on a virtual journey to view the role of ICT on teaching and learning in our schools and teacher education institutions. To give us a baseline, we will go back in time to look at the nature of schools when computers first appeared. Then, to see the stage reached in the use and adoption of ICT, we will view present developments taking place in ICT and the ways that ICT are changing teaching and learning. And we will dare to venture into the near future to try to anticipate the ways education is being transformed by the use of ICT. Five predictions about ICT are made and implications for education are discussed. Fasten your seat belts for a short but exciting journey, backwards and forwards in time.

In many ways, this is a personal account as I am fortunate to have been actively involved throughout the past and present eras through which the journey takes us, and during my academic career I have worked on national and international projects on uses of ICT in instructional settings. The future, of course, awaits us all.

A journey back in time
The very first commercial computer for business applications was launched in 1951, only 60 or so years ago. The chairman of International Business Machines Limited (more familiarly known as IBM) said in a speech before the launch: “I think there is a world market for maybe five computers.” How wrong that prediction turned out to be!

About a decade later, my first university appointment coincided with the University of Queensland acquiring its first computer. In those days you could count the numbers of computers and this was only the third computer in all of Australasia. I remember it well – it was a GE50, and the 50 might have stood for 50 tons for it occupied a whole room. Each department of the university was invited to send a staff member to learn about this ‘new’ machine and, as newest member in my Department, the Professor called me in and said, “I’m not quite sure what these computers are but I think they could be important. You should find out about them.” He was right! The rest, as they say, is history.

The early 1980s saw the advent of microcomputers in schools, so called to distinguish them from minicomputers and mainframe computers in universities. Microcomputers came with a variety of names – Apple, BBC, Commodore, Atari, Apricot. In 1981, IBM, the company whose chairman had once predicted that five computers would suffice for the whole world, released what it called a Personal Computer, giving rise to the use of the term PC today.
Schools and teacher education departments up until that time (the early 1980s) could mostly be described as traditional. One of the schools that I attended as a boy happened to be where my great grandfather had been head teacher, and I saw at first hand how little schools had changed from the nineteenth century. We sat at desks neatly arranged in rows, putting our hands up when the teacher asked the class questions. Everything was regimented, we copied what the teacher wrote on the blackboard, and most learning was by rote. The teacher very much controlled what we learned, how we learned, and when we learned.

But those first microcomputers began to bring about gradual change in classrooms around the world as innovative teachers explored their use. It is true that in the early days there was an emphasis on programming and much early software was of the drill and practice variety imitating current teaching behaviour. However, simulation and problem solving packages, adventure games and other new kinds of software slowly began to appear. In 1984 a book called *Computing in Schools* was published (Anderson 1984) that provided the first snapshot of how teachers across a nation were exploring the uses of computers in instructional settings. Shortly afterwards, the regional UNESCO office in Bangkok published *Developing Computer Use in Education: Guidelines, Trends and Issues* (Anderson, 1986). Three years before, I had introduced a new course in the teacher education program at Flinders University called Computers in Schools. Looking back, it seems to me that around 1984 can be thought of as a baseline – the beginning of the use of computers in schools in Australia and in other countries like Britain, Singapore, France and the United States. This beginning has been termed the *emerging stage* in the use of ICT in schools (Anderson and Weert 2002).

**Jump to the present**

What characterises the present from the journey back in time is that computers began to be linked together, not necessarily physically but by an intricate web spanning the globe. We know this as the world wide web, the internet, or just net as it is often called. In an article titled *Year of the Net* (Anderson 1997), I wrote:

> 1996 will be remembered for above all as the year that the Internet made its initial, far-reaching impact, not only on education institutions, but also on much of the rest of human activity.

Other authors at that time (Petre and Harrington 1996) identified five "core technological shifts" that would lead to the current online revolution: PCs became immensely more powerful; PCs were widely adopted; PCs became networked; costs of telecommunications fell; and analogue communication became digital. Although writing about developments in Australia, Petre and Harrington could have been describing a global trend when they stated:

> ... Australia is facing another major global paradigm shift ... It involves the global production, dissemination, storage and analysis of digital information over online networks such as the Internet. (Petre and Harrington, 1996, p. 9)
Around this time, the term ICT, or Information and Communication Technologies, came into the lexicon. ICT include, of course, computers – all the types around today like desktops, laptops, notebooks, palm-held pilots, computer servers, and super computers. But ICT include much more: video, CD and DVD, radio and television, printers, data projectors, and interactive white boards; also satellites, fibre optics, Wi-Fi, modems and routers, and all the other myriad network equipment that enables electronic mail, short message service programs (SMS), and video telephone calls. As well, ICT embrace that must-have communication accessory – the mobile or cellular phone – along with digital imaging and sensing, global positioning devices, and a range of other tools that make up our computing systems, our telecommunications, and our global networks. Also included under the ICT umbrella are a family of transmission technologies for voice over internet protocol (e.g., Skype) together with technologies for computer mediated social interaction and networking (e.g., Facebook, Twitter, MySpace, LinkedIn).

The very air we breathe literally buzzes with all kinds of information signals. ICT encompass all the technologies by means of which we can detect these signals, interpret them, and exchange them with others. ICT is a plural term that refers to many technologies. It is an all encompassing term that includes the full gamut of electronic tools by means of which we gather, record, and store information, and by means of which we exchange and distribute it to others.

ICT have had an enormous impact on every aspect of society. “A third industrial revolution” is how UNESCO describes the impact in a 200+ page report, *Towards Knowledge Societies* (UNESCO 2005).

From the vantage point of the present, it is clear that ICT heralded a paradigm shift in education in that its use in schools is changing how teachers teach and how students learn. A new UNESCO publication (Resta 2009) describes the changing roles of teachers brought about by the use of ICT in schools (Table 1).

**Table 1: Changes in teacher roles resulting from the use of ICT**

<table>
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<tr>
<th>Changes in Teacher Roles</th>
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<tbody>
<tr>
<td>A shift from</td>
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<tr>
<td>knowledge transmitter;</td>
</tr>
<tr>
<td>primary source of information</td>
</tr>
<tr>
<td>teacher controlling and directing</td>
</tr>
<tr>
<td>all aspects of learning</td>
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<tr>
<td>to</td>
</tr>
<tr>
<td>learning facilitator, collaborator, coach,</td>
</tr>
<tr>
<td>knowledge navigator, and co-learner</td>
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<tr>
<td>teacher giving students more options and</td>
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<tr>
<td>responsibilities for their own learning</td>
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The changing role of teachers is aptly summed up in the quip that teachers have moved from being “sages on the stage” to becoming “guides on the side”. The teacher is no longer the all-knowing authority. Perhaps the new role can be likened to that of a team coach or the conductor of an orchestra whose responsibility is to bring out the best performance in all players.

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In the same way that teachers’ roles are changing as a result of the use of ICT, so are the roles of students changing, as seen in Table 2.

**Table 2: Changes in student roles resulting from the use of ICT**

<table>
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<tr>
<th>Changes in Student Roles</th>
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<tr>
<td>A shift from</td>
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<tr>
<td>passive recipient of information</td>
</tr>
<tr>
<td>reproducing knowledge</td>
</tr>
<tr>
<td>learning as a solitary activity</td>
</tr>
<tr>
<td>learning collaboratively with others</td>
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Students in classrooms where ICT are routinely used are likely to participate in “virtual” excursions and be active researchers, searching the web for information to complete individual projects, communicating via email and blogs with students and teachers in other schools, and reaching conclusions on the basis of evidence gathered.

Such classrooms where teacher and student roles are changing in the direction shown in Tables 1 and 2 have moved well beyond the emerging stage noted in the previous section to what are termed the applying and infusing stages (see Figure 1). These different stages of ICT development that educational systems and schools pass through in the use and adoption of ICT were first described in Anderson and Weert (2002) and Anderson and Glenn (2003), and further amplified in UNESCO’s *Regional Guidelines on Teacher Development for Pedagogy-Technology Integration* (Majumdar 2005).

![Figure 1: Stages of ICT development that educational systems and schools pass through in the use and adoption of ICT](image-url)
A tale from the future
Let us move now to the distant future – to the year 2157 – in a short story told by science fiction writer, Isaac Asimov. The story was published in the same year that the first commercial computer was launched (Asimov 1951). To provide some context, Margie, a girl aged 11, is talking with her friend Tommy, who is 13 and who has been poking around in the attic of his home where he finds something quite old. Here is a short excerpt:

Margie even wrote about it that night in her diary. On the page headed May 17, 2157, she wrote, “Today Tommy found a real book!”

It was a very old book. Margie’s grandfather once said that when he was a little boy his grandfather told him that there was a time when all stories were printed on paper. They turned the pages, which were yellow and crinkly, and it was awfully funny to read words that stood still instead of moving the way they were supposed to – on a screen, you know. And then, when they turned back to the page before, it had the same words on it that it had when they read it the first time.

“Gee,” said Tommy, “what a waste. When you’re through with a book, you just throw it away, I guess. Our television screen must have had a million books on it and it’s good for plenty more. I wouldn’t throw it away.”

“Same with mine,” said Margie. She was eleven and hadn’t seen as many telebooks as Tommy had. He was thirteen.

Back to the present
Asimov’s story about telebooks might have seemed a little far-fetched when first published in 1951 but similar electronic books or e-books are now readily available. Project Gutenberg, for example, the first source of digitised books on the internet, has steadily grown in size and now contains 30,000 public domain titles. Full text versions of all titles are freely accessible for downloading from Project Gutenberg’s website (see Figure 2).

Figure 2: Project Gutenberg offers e-books from the public domain for free downloading

Not available outside the United States until recently, Amazon Kindle is a wireless reading device for downloading books and other reading matter from the Amazon.com website (Amazon.com launched a limited international version of Kindle in October 2009). The
Kindle, shown in Figure 3, is a reader that uses high-speed mobile telephone networks to download books, magazines, newspapers, and other documents, and does not need to be used with a computer. The e-ink display of Kindle reads like real paper, claims the company. More than 350,000 books, newspapers and blogs are accessible for downloading (for a fee). A new Kindle application is now available for the iPhone.

Figure 3: Amazon’s Kindle, a wireless device for reading books and newspapers

Other companies like Sony also market an e-Reader, similar to the Kindle, for reading books on an electronic paper display. Google, too, has a vast collection of books on its website in Google Books, which may be accessed from its browser page, or more directly from http://books.google.com/books. Figure 4 shows a few of the hundreds of titles from its section on fiction (literature). Thousands of titles are available in non-fiction with its subsections on philosophy, economics, political science, linguistics, mathematics, physics, chemistry and biology.

Figure 4: A small sample of books from Google Books (literature)
The ready availability of this vast source of digitised books and other reading matter from the internet has implications for classrooms and school libraries in many parts of the world. For the offshore Doctor of Education program that Flinders University conducted for Rajabahts in Thailand, for instance, I assembled a collection of scholarly, refereed educational journals that were freely available on the web to augment the severely limited resources in these institutions’ libraries. Another useful source of research information for this doctoral program was UNESCO’s portal on ICT in education with its sections on online books, theses, research publications, and newspapers, as well as its resources for teacher educators (see Figure 5).


Figure 5: Part of the home page of UNESCO’s education gateway on ICT

The near future – ICT predictions
Not forgetting how wide of the mark was the IBM chairman’s prediction about the world need for computers, let us nevertheless cautiously look to ICT developments that may occur in the near future. Here are five tentative predictions.

One prediction is that the very high popularity of social networking websites such as Facebook, Ninemsn, Twitter, and others will continue. According to Nielsen Online as reported in The Australian (6 October 2009), Facebook was the fourth most visited site in Australia in the preceding month (Google was the most popular). It was reported that “On average, one quarter of all internet use in Australia is on Facebook”, a staggering 6.5 hours of an average 26.5 hours online each week. Interest in Twitter is also experiencing remarkable growth: according to the same report, visits to it by Australians in the 12 months to June grew almost 1000 per cent compared with the previous period. There is evidence, too, that social network use via mobile phones is increasing rapidly. These particular websites may turn out to be passing whims. On the other hand, the popularity of such online social networking seems to reflect a deep, inner need to communicate with others, particularly to share information like photos and to organise events.

A second prediction is that touch-screen technology will change how users interact with devices like mobile phones and PCs. Already users with newer smart phones like Blackberry and iPhone point and touch icons on the screen and use fingers to scroll. Fingers are used also
to resize pictures by pinching or stretching them. PCs are also now coming on the market with touch-screen capabilities. What touch-screen technology does, once users adapt to this new way of interaction, is to make these forms of ICT even more personal.

A third prediction, arising from a development noted in the previous section, is that all knowledge in the form of books and printed matter will rapidly become digitised. Mention is made above of collections of some thousands of books from companies like Amazon.com, Sony and Google. Significantly, Google recently announced (September 2009) that it has signed an agreement with US publishers giving the company the right to digitise millions of books. It should be noted that competing companies have strongly protested over this move by Google, and the agreement still has to obtain regulatory approval. But Google is a powerful company and, as one close Google watcher noted, its long-term goal is:

...to let you search the full text of any book ever published, and then provide the option of reading the book online (for selected books), purchasing the book (from selected booksellers), or finding out where you can borrow a copy of the book (from participating libraries) [Miller 2008].

Such a goal, if achieved, will well surpass the scenario from 2157 painted by Isaac Asimov.

Advancing a little further into the near future, a fourth prediction is that smart phones will become more like computers as computers become more like smart phones. Under this prediction, we are likely to see a convergence of mobile and PC technologies as rival chip manufacturers enter each other’s territory.

Coupled with the prediction that smart phones and computers will become more like each other, a fifth prediction is that what is called cloud computing will become more pervasive. Cloud computing is where computing resources (like, for example, office applications) are held on remote servers that may be accessed by individuals using a web browser rather than having these same resources on their PCs. If cloud computing takes off in the way predicted here, PCs will no longer need to have gigabytes of memory to hold applications and, in turn, operating systems can be trimmed down from their increasingly gargantuan sizes.

Arising from these various predictions, it seems likely that a cross between a smart phone and a touch-screen personal computer will emerge. Such a device (see Figure 6) will be held in the hand like a mobile phone but it will have a larger surface, something like a writing tablet; and it will be used for all kinds of communicating – browsing the internet, emailing, reading books and other materials online, phoning and texting, and social networking with friends and colleagues. This new device, yet to be invented, will serve as a communications tablet, or CT for short. To capitalise on the runaway success of devices like the iPod, iPod touch, and iPhone, it may even be given the name iCT.
Implications for education

While it is not easy to spell out what are the implications for education of these various predictions since they are in part speculative, nevertheless educators need to try to keep abreast of the latest developments in ICT. To take an example, let us touch briefly on one prediction made in the previous section, that concerned with social networking. From the statistics presented above, it is clear that social networking websites are attracting phenomenal interest. Although the data do not provide any breakdown by age, observations would suggest that Facebook, for instance, is most popular among students at schools and universities, that is, among teenagers and young adults. If these statistics for Australia approximate to what is happening elsewhere, then educators cannot afford to ignore such a major phenomenon where users (students) are spending up to a quarter of all their time online interacting with Facebook. Nearly all Australian universities now have established pages on Facebook and some also on Twitter. One of the concurrent sessions at this conference has the sub-theme Capitalizing on Social Networking for Collaborative Learning (Session 2D), and the speakers in that panel will do more justice to this topic than can be done in the space here.

A critical question for educators is how to prepare the next generation of teachers for a future where ICT is accelerating at such a pace? Significantly, at least three concurrent sessions at this conference address this question:

- 21st Century Teacher Professional Development (Session 1B)
- Preparing the Next Generation of Teachers (Session 2B)
- The Impact of ICT on Teacher Education Programmes (Session 3B)

UNESCO Bangkok has an important project underway called The Next Generation of Teachers led by Dr Miao; and UNESCO Headquarters in Paris also addresses the question in a book about to be published, Teacher Development in an E-Learning Age: A Policy and Planning Guide (Resta 2009). To give a taste of this new publication, Figure 7 presents a four-strand learning model for teacher development that provides a framework for the book’s
The model also provides a potentially useful template for new courses in teacher education.

The horizontal dimension of the model in Figure 7 is Content, which is represented as a continuum with three points of reference; while the vertical dimension is Communication, also with three points of reference. Within this two-dimensional model are depicted four categories of learning:

1. Information repository
2. Online (distance) course
3. Blended (extended) course
4. Communities of practice

The usefulness of the model is that it provides a broad framework for developing new teacher education programs. Corresponding to each of the categories of learning, four foci can be identified, namely:

1. Accessing online resources
2. Developing online courses
3. Blended learning
4. Networked communities of practice

**Figure 7:** A four-strand model of e-learning for teacher development
This new UNESCO publication (Resta 2009), compiled by an international team of writers, contains comprehensive chapters on accessing online resources for teacher development, blended learning, and networked communities, as well as other chapters on essential conditions, organisational issues, and standards and assessment of e-learning. Again, several of the concurrent sessions at this conference focus on one or other component within this four-strand learning model:

- Blended learning in practice (Session 1C)
- Higher education networks and learning environment (Session 3C)
- Collaborative learning (Session 4B)

**Future perfect**

Will education have gone beyond the infusing stage to the transforming stage with the current and anticipated adoption of newer ICT in the classrooms of the world and with the development of new teacher education programs designed for the next generation of teachers? The theme of this year’s 13th UNESCO-APEID Conference is *ICT Transforming Education* and all delegates presenting papers are discussing elements of this transformation in their countries.

To close, consider two brief comments from experts in fields closely allied with education: public libraries and the media. The first comment comes from the Head Librarian of the British Library whose holdings include 14 million books, 920,000 journal and newspaper titles, 58 million patents, and 3 million sound recordings. Interviewed on radio as I was writing this paper (October 2009), he was talking about the library's digitisation of all their newspaper holdings. He said that if people want to read through the millions of pages sequentially to find an item, then they can. On the other hand, if they want to do an online search and locate what they are looking for in a few seconds, they are now able to do so. “That”, he said, “is transformation”.

The second comment comes from an address to the World Media Summit in Beijing (*The Weekend Australian*, 10-11 October 2009) by Rupert Murdoch, chief executive of the global media empire, News Corporation, who made this observation. In the not-so-distant past, companies within News Corporation like print, radio, television, film, sports, and social networking, were quite separate entities. However, digitalisation has made old boundaries redundant and new business models are needed. The media is being transformed, which in turn is transforming the world.

In the case of learning institutions – schools and departments of teacher education – transformation will have taken place when the whole institution, its ethos and all its practices, are so changed by the use and adoption of ICT that new education models are needed. Education practice is being transformed and there is no going back to the old days.

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1 The future perfect, one of the basic tenses in English, is used to describe something that has not yet happened but is anticipated will occur before another event takes place. eg. He will (or shall) have finished by the time you come.
References


The Australian. 2009. Facebook habit soaks up net time. The Australian (October 6, 2009, p. 34).
