Chapter 4 – Reconceptualising ICT

Information and communications technologies (ICT) are central to this thesis. The advances made by various technologies over recent years have implications for teaching and learning in schools, colleges and other educational institutions (Farren 2006: 61). But there are dangers in taking a sycophantic view of technologies (Snowden 2005: 6). To avoid adopting a sycophantic or a sceptical view I adopt a critical stance in evaluating my approach to pedagogy, and engage critically with the ideas of key thinkers in the literatures. In this chapter I will explore how technologies, both general technologies and ICT are conceptualised generally. In doing this I will pursue some of the recent history of new technologies and how they have been conceptualised. I will then set out a basis for my original idea of reconceptualising ICT as political action. My experience is that technologies are often treated unproblematically. In this first section I place my experience of technologies into context and, by engaging with various conceptualisations of technologies, provide the basis for the development of my reconceptualisation.

I have referred previously to my background as a teacher of Science. Having taught Science for some years I undertook teaching the new school subject called Technology. This subject is much broader than ICT and could be regarded as dealing with general technologies. The syllabus for this subject divides the knowledge and skills required in the subject into four major sections: Communications, Craft and Materials, Energy and Control, and Technology and Society. While the subject Technology contained elements of information technologies, its scope included the areas of electronics, energy conversions, structures, materials processing and the social implications of using technologies. For clarity throughout this section, whenever I refer to technolog(y)/ies I am referring to general technologies. When I am dealing with computing related matters I will refer to information technologies (IT) or information and communications technologies (ICT). There may be times when the distinction between these is not clear and this is because I believe that a sharp division between various technologies is somewhat artificial. For example, while computers are clearly concerned with information and communications technologies it is the case that materials processing, energy conversions and many other technologies are also centrally concerned. I see a value in taking a more holistic view of technologies.

While taking part in professional development courses, both as tutor and learner, for the purpose of teaching this new subject, in common with colleagues, I defined technology as 'the application of science'. It is likely that this interpretation of technology is a common view of technology and extends back to Bigelow (1830: 338), who referred to technology as 'the practical applications of science'. This is part of the confusion that links science and technology as if they were different expressions of a single entity. This has resulted in science and technology being seen as 'an indivisible pair' (Rose and Rose 1969). The common perception of science and technology as a pair is underlined by Mayr (1976: 666) when he comments '... practical usable criteria for making sharp neat distinctions between science and technology do not exist'. However this conflation of technologies and science is confounded by histories of technology that extend their treatment to a period before Mesopotamian civilisation (Derry and Williams 1960), whereas the scientific revolution is usually afforded a much shorter life. It is curious that in an authoritative history of technology in a book extending to nearly eight hundred pages that the authors decline to define or explain what they mean by Technology. Instead, they treat it unproblematically. In some cases the distinction between science and technology is seen in terms of the theory/practice debate: science offering the theory that informs technology's practice. One account sees them as poles of a magnet, far apart but nonetheless part of a whole (Mayr 1976: 666). Sparkes (1992) points out that even though science and technology overlap in an area which might be referred to as 'applied science', there are a number of important differences between the two. These differences include the goal of science as the pursuit of knowledge and understanding for its own sake, whereas the goal of technology is to create artefacts and systems to meet people's needs. The Irish Department of Education and Science, in defining the aims of the subject Technology leaned towards Sparkes' view: 'Technology is the achievement of human purposes through the disciplined use of materials, energy, and natural phenomena' (Department of Education and Science 1989: 2). While this statement could stand considerable analysis it places technologies clearly within the realm of human agency and admits the potential social purpose of technologies as opposed to a view of technology as having agency of its own that may dominate human purposes (Friedman and Kahn 1997: 302-311).

The debate about the provenance of technology has a parallel in information technology. Some date the start of computing to the differential machine which Charles Babbage devised in 1827 to calculate logarithmic tables or to his analytical engine devised but not built in the 1830s. Because of this work Babbage was known to some as the ‘father of computing’ (Bowden 1971). The advent of modern computing probably arrived with the invention of the ‘Colossus’ in 1943. The Colossus was an electronic computer built at the Bletchley Park research centre in Britain and designed to crack the German Enigma coding system used to send secret messages for military purposes. At the same time the 'Harvard Mk I' was built at Harvard University with backing from IBM. The Harvard Mk 1 was a general purpose computer. These computers were among the first of the ‘first generation’ of electronic computers. ‘ENIAC’ (Electronic Numerical Integrator and Computer) which was completed in 1946 is regarded by some as the first modern computer. A key feature of ENIAC and other first generation computers was their sheer size. ENIAC weighed about 30 tonnes. The size and expense of building and maintaining these computers suggested that they would only ever be owned by governments and major corporations. Thomas J. Watson, chairman of IBM, is reputed to have remarked that, “I think there is maybe a world market for five computers”. There is some doubt if Watson did, in fact, make the remark (Maney 2003).

The next major step in the history of computing was the invention of the transistor in 1947. Transistorised computers are normally referred to as 'Second Generation' and dominated the late 1950s and early 1960s. Despite using transistors and printed circuits these computers were still large and power hungry and were largely confined to the military, government and university establishments.

The explosion in the use of computers began with 'Third Generation' computers. These relied on the integrated circuit or microchip. The first integrated circuit was produced in September 1958, but computers using them didn’t begin to appear until 1963. In 1971, Intel released the world’s first commercial microprocessor, the 4004. ‘Fourth generation’ computers were developed, using a microprocessor to locate much of the computer's processing abilities on a single chip. The microprocessor allowed the development of microcomputers. These personal computers were small and cheap enough to be available to ordinary people. The first such personal computer was the MITS Altair 8800, released at the end of 1974, but it was followed by computers such as the Apple I and II, Commodore PET, Zinclair ZX and Spectrum and importantly the IBM PC in 1981. Although the capacities of computers, in terms of speed, processing power and storage, have increased since 1981 it is generally accepted that modern computers still belong to this ‘fourth generation’ of computers. The key characteristics of fourth generation computers that enabled their proliferation is their small size and low cost. While these factors allowed ordinary people to get their hands on computers throughout the 1970s and 1980s it was something of an enthusiast’s activity and it was not clear what non-enthusiastic people would do with them. The entry of computers into the lives of most people was dependent on the development of new software and cheap communications technologies.

While a short history like this gives some indication of the origins of computers and of the level of change that promoted their development, some people think other aspects of their origins are more important. For some commentators the warlike origins and their role as an instrument of war is an important element in the provenance of computers (Kahn and Friedman 1998: 160). The military aspects of computers can be found at many stages of their development.

In response to the Russians launching Sputnik, the first technologically constructed satellite, into space in 1957, President Eisenhower formed ARPA, the Advanced Research Projects Agency (Krantzberg 1962). The people at ARPA understood that a post-nuclear America needed a command and control network that could link city to city and base to base. But they were aware that no amount of protection could save such a network from nuclear attack and the headquarters would be particularly vulnerable. The solution provided by the Rand Corporation to ARPA was a network without a central authority and which would continue to operate even if it was in tatters. ARPAnet was born in 1969 with four nodes on the network. ARPAnet was opened to non-military users later in the 1970s. But these non-military users were mainly the large universities which had major military research contracts. ARPAnet was eventually divided into two networks, the civilian Internet and the military Milnet. At this point the Internet was still largely a technical tool. The Internet gained its ‘friendly face’ when the World Wide Web was invented by Tim Berners-Lee in 1989. Berners-Lee was a physicist working at Conseil Européen pour la Recherche Nucléaire (CERN), otherwise known as the European Particle Physics Laboratory. He was looking for a way for physicists to share information about their research – the World Wide Web was his solution.

Berners-Lee’s invention provided a key element in opening up computers to the public at large. In all there were four key elements. These elements were small cheap computers developed as the ‘fourth generation’ of computers; the availability of ‘friendly’ and easy-to-use software with point and click interfaces like Windows and MacOS; software which appealed to people like the World Wide Web, email, forums; and, finally, broadband communications. Integrated circuits made the hardware cheap enough for ordinary people to buy. Point and click interfaces including Windows, MacOS and web browsers enabled non-technical users to make use of the technology. The World Wide Web, email, and social networking tools provided non-technical users with a reason to use computers. Broadband technologies provided the Internet with sufficient speed to support user-oriented applications.

In addition to supporting non-technical users these factors have opened up the possibility for interactive education undertaken in a collaborative way with new and novel means of representation. Making a choice between focussing on the potentials of the technologies and on the origins of information technologies has spawned widely diverse views of computing. The poles of these views are represented on the one hand by an enthusiastic or perhaps sycophantic view and on the other by a sceptical view. Focussing on the technology itself, one side takes the view that technology is beneficial and the only real questions are technical ones about how we use the technology (see Bromley 1998: 2). The second view is that technology is inherently harmful and must be avoided (Oppenheimer 1997; 2005; Postman, 1995). It seems to me that both of these views are instrumentalist, perhaps even fundamentalist, and arise from a perspective where technology has agency of its own (Friedman and Kahn 1997: 302-311). In the following sections I will examine both of these positions and propose a third view that sees technologies as neither inherently good nor evil but dependent on the purposes of the people using them. If the people using them have transformational purposes then the technology can be transformational. In this way I take a view of technology that is not value free and must be treated problematically. When choosing to use technologies it may be important to focus on the agency of people, not the agency of the technology.

The evangelistic view of technology

Irish government policy in relation to ICT in schools was developed in response to the International Data Corporation (IDC) ranking Ireland in the third division, at position 23, ‘in terms of its preparedness for the information age’ (Government of Ireland 1997: 14).

The policy document, stating that there are compelling reasons for integrating ICT into schools, lists reasons that bear a striking similarity to the rationales of Hawkridge *et al*. (1990). Hawkridge provides seven rationales for the introduction of ICT into schools. These are social, vocational, pedagogic, IT industry, cost effectiveness, special needs and catalytic rationales. The government policy lists four categories of reasons for integrating ICT into schools. First it argues that there are social benefits and cites the Bangermann Report (European Union 1996) on the dangers of the creation of a two-tiered society of information 'haves' and 'have-nots'. The policy document argues that there are vocational and economic reasons. These reasons are based on the claim that 'knowledge and familiarity with technology will be an important dimension of employability in the information society' (Government of Ireland 1997: 15). Third, there are pedagogic reasons. 'ICT can improve the quality of educational experience by providing rich, exciting and motivating environments for learning' (*ibid:* 15). Finally, there are catalytic reasons for ICT integration. 'The use of computers can accelerate positive trends such as increased emphasis on information handling and problem solving and reduced emphasis on memorising facts' (*ibid:* 16).

The uncritical approach to the use of technology in schools was extended by the Minister for Education and Science, Mr Michael Woods. In announcing the second phase of Schools IT2000 in December 2001 he said:

> The pace of development in information and communication technology is blistering. My vision is to equip our young people to take advantage of these new technologies at the earliest possible stage in their education both to give them the ability to use the technology and to open up for them the wonderful vista of resources provided by such facilities.
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> (Woods 2001: 1)

The thrust of Hawkridge's rationales can be seen in government policy around the world (see European Commission 1996; Singapore Ministry of Education 1997; Government of Ireland 1997). The underlying assumption is that computing technology benefits all students in a neutral manner which is independent of unequal distributions of power, and independent of class, gender, ethnicity or other factors (Bromley 1998: 2). O'Dwyer (1998: 5-11), Director-General for Education, Training and Youth of the European Commission, continues this approach by focussing on how schools get the technology. He referred to the numerous studies which showed the educational benefits of ICT, and then outlined the recognised obstacles to the use of educational multimedia in schools:

- Lack of user-friendly multimedia equipment and software for teachers and pupils;
- Insufficient quantity of equipment, which is often technically obsolete, sometimes insufficiently used and rarely connected to telecommunications network;
- Insufficient quality and quantity of educational software adapted to the needs of users;
- Difficulty of integrating educational multimedia into teachers' educational practice; and
- Lack of teacher training and information.

O'Dwyer's approach is to treat technology in an instrumental way. The questions are of a purely technical nature dealing with how to apply the technology. The underlying assumption is that anything involving new technologies must be an improvement (Bromley 1998: 2).

Jones *et al.* (1994) focus on access to technology but from the 'equity' point of view. Their concerns were with the 'equitable and effective' access to technology. In their study they describe four indicators – connectivity, ubiquity, interconnectivity, and equity – that denote equitable and effective access to technology. The indicators proposed by Jones *et al.* (1994) focus on a combination of technology and human intervention. So while they see a need for technology to be ubiquitous – it must be everywhere – and there must be connectivity – there is a need for networking, both local and wide – they also see a need for interconnectivity. In their view interconnectivity is not about connecting the technology but about connecting people. Equitable access includes access that allows students and teachers to collaborate in various ways. Connecting people is not enough; there must be equity among users. So specific steps must be taken to ensure that minority and marginalised people gain access.

Ceruzzi (2005) proposes a reason for the determinism surrounding technology and ties it to the so-called Moore's law. Gordon Moore, one of the founders of Intel, the microchip manufacturer, observed in 1965 that the number of transistors that could be placed on an integrated circuit had doubled each year since the integrated circuit was invented (Moore 1965 cited in Ceruzzi 2005: 584). This became known as Moore's Law. The implication of Moore's Law is that computers would increase in power exponentially. The increase in the number of transistors that could be placed on an integrated circuit has been such that Moore's law has held true since Moore's observation, with the slight modification that the time interval for doubling has stretched to eighteen months. Moore's Law provides the basis for the increasing power and decreasing costs that have allowed computers to become part of our everyday life. The increasing power provides the capacity for user friendly applications, while decreasing cost makes it possible for ordinary people to gain access. In this way the effects that Moore's Law described have played a key part in providing the plethora of new technological creations referred to above and the impact these have had on the way we live, work and learn. Ceruzzi (2005: 586) maintains that public acceptance of technological determinism has been driven by Moore's Law because the continuing expansion in the power of computers has led to a continuing expansion in the capability of computers. This in turn has led to the notion that computers determine where we can go and what we can do. Microsoft contributed to this idea with its successful advertising slogan in the 1980s: 'Microsoft – where do you want to go today?' In support of his claim that Moore's Law has driven technological determinism, Ceruzzi cites cases of people feeling powerless to shape, much less resist, the models offered by particular technologies.

The sceptics' view of technology

While there is a large body of digital evangelists, there is a smaller but equally significant body of digital sceptics. Many of these see technologies as a threat to a better way of life that predated modern technology. In the brief survey of technologies given above I have indicated that technologies can be traced back to the origins of humankind. With this in mind, and as part of my process of understanding better what I do and of improving what I do, I see a need to examine whether technologies have always been a threat to humankind or if modern technologies are fundamentally different to technologies that preceded them. Marcuse (1964) suggests that modern technologies are different. He criticizes both communist and capitalist countries for their lack of authentic democratic processes. Neither type of society creates equal circumstances for its citizens. Marcuse discusses the factors which inhibit criticism and analysis of society. He believes that people are not free because they function within systems. If people were really free, they would be free from these systems. He regards these systems as the result of technological development: 'A comfortable, smooth, reasonable, democratic unfreedom prevails in advanced industrial civilization, a token of technical progress' (Marcuse 1964: 4). Ideas like freedom of thought, speech and conscience which promoted and protected free enterprise, were originally critical ideas. These have become institutionalised and have lost their critical aspect. Marcuse sees the technological products of society carrying with them prescribed attitudes and habits which bind the consumer to the producer. However these products provide a good way of life, better than we have had before, and so consumers are seduced into 'one-dimensional thought and behaviour' which works against critical examination.

Despite the view that technology has provided a 'good way of life', a number of commentators challenge this position in relation to digital technologies and criticise their use in education and elsewhere. Oppenheimer (1997) asserts that '…there is no good evidence that most uses of computers significantly improve teaching and learning'. He supports his position by citing claims for the impact of earlier technologies, like television and radio, on education that have never been realised. In 1922, Edison claimed that 'the motion picture is set to revolutionise education…and will supplant the use of text books.' In 1945 the director of Cleveland public schools radio station claimed that radios would, in time, be as common in the classroom as the blackboard. B.F. Skinner (1954: 94), the psychologist, claimed that teaching machines and programmed instruction would enable students to learn twice as much with the same effort. Oppenheimer sees current initiatives to introduce computers into classrooms as part of the same technological 'delusion' and draws on Cuban's (1986) conclusions that as each round of technological advances failed to achieve their promise, a pattern emerged that blamed a range of other factors: lack of money, teacher resistance and school bureaucracy, but never the technology. Eventually, when criticism began to be directed at the technology, a new technology was rolled out and the sequence started all over again. Oppenheimer argues that 'The purpose of the schools [is] to, as one teacher argues, 'Teach carpentry, not hammer'…we need to teach the whys and ways of the world. Tools come and tools go. Teaching our children tools limits their knowledge to these tools and hence limits their futures' (Oppenheimer 1997: 62).

I have considerable sympathy for this final point but it begs the question: Does 'using technologies' and 'teaching tools' amount to the same thing; or are there ways of using technologies that are not simply teaching tools? From my experience I can see that teaching IT skills is frequently about teaching the tools. For example, teaching word processing skills is often about teaching MS Word which amounts to teaching a particular tool. But I contend that a word processor could be used in a life-affirming way that involves learning tools, and learning the tool is not an end in itself but a result of the life-affirming practice. In this way using ICT can be liberating rather than limiting. I will provide instances of such uses of ICT in the next chapter.

Postman (1995) argues that while ICT may provide gains they also involve losses. Like Oppenheimer he draws on the recent history of technology implementation to support this view. He claims that in the past, when technology has had positive effects, it has also carried with it disadvantages. Often the disadvantages outweigh the advantages:

> After all, anyone who has studied the history of technology knows that technological change is always a Faustian bargain: Technology giveth and technology taketh away, and not always in equal measure. A new technology sometimes creates more than it destroys. Sometimes, it destroys more than it creates. But it is never one-sided.
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> (Postman 1990: 2)

Postman's 'Faustian bargain' has resonances of McLuhan's 'extensions' and 'amputations' (2001). McLuhan argued that all technologies are 'extensions' of the body; for example the car is an 'extension' of our feet. But while we seek the car for the 'extension' we also receive an 'amputation' in the sense that the ability of our legs to walk diminishes. Postman sees cultures as classed into three types: tool-making, technocracies and technopolies. In tool-making societies tools are used to solve immediate and urgent problems of physical life or to serve the symbolic world of art, politics or religion. In Postman's view, making a spear to hunt or a watermill for power represent the former while building a cathedral or a castle represent the latter. These tools, he says, did not attack the dignity or integrity of the culture they were brought into; they contributed to it. In a technocratic culture, tools play a central role in the thought-world of the culture. So everything in the culture is subject to and must give way to their development. The technocratic tools attack the culture in an attempt to become the culture. In a technocracy the technocratic culture co-exists with the tool-making culture. However, in a technopoly the tool making culture has lost the battle, and the meanings of tradition, social mores, myth, politics, ritual, and religion are defined by the new 'totalitarian technopoly'. As a result of this analysis Postman comes to several conclusions, among them that computers have no place in classrooms. The basis for this argument is that in a traditional classroom there is balance between individualised learning, competition, and personal autonomy on the one hand and group learning, cooperation, and a sense of social responsibility on the other (Postman 1995: 17). According to Postman, computers in the classroom threaten that balance and ensure that private learning and individual problem solving will dominate to the detriment of communal speech. This could be seen as the Faustian bargain. Private learning gains while communal speech suffers.

While Postman has provided a carefully argued position, Kaplan (1995: 34) has drawn attention to the fact that Tuman, another critic of 'electronic writing technologies', makes his criticism of computers in the classroom on precisely opposite grounds: claiming that they 'shift the primary focus of literacy away from the self-contained text and toward a new kind of interactive discourse akin to conversation...' (Tuman 1992: 90). It appears that Postman is opposed to computers because they eliminate communal speech while Tuman is opposed to computers because they promote interactive discourse. If technologies have inherent logics Kaplan questions how the underlying logic of computing could lead to two such radically different causes for the loss of print literacies. It appears that Postman and Tuman are making their case based not on the inherent logics of computing but on particular uses that computers have been put to. It would not be unreasonable to infer that Postman's and Tuman's work and Kaplan's analysis suggest that we need to look not at technological determinism but at human agency as a means of envisioning a desirable future and inventing ways of bringing it about (Schön 1991: 16).

The attempt to disentangle the logics underlying computing is not confined to Kaplan's analysis. In the brief account of the recent history of digital technologies presented above, it is clear that military involvement was a key feature in the early development of the modern computer and of the Internet. Military involvement has been a key feature since. Bromley (1998: 13) argues that the environment in which a technology is developed – especially the power relations there – instils in the technology traits that favour some uses rather than others. The relationship between computing and the military is longstanding. Bromley's claim is that this relationship contributes a propensity toward the imposition of a military worldview onto computing. The military world view is one of 'command and control'. The symbiotic relationship between the military and computing has ensured that while the military provided 'command and control' as a philosophy, computing has enabled 'command and control' as a practice. The combination of the two has enabled 'command

and control' to develop into 'command, control, communications and intelligence' (Bromley 1998: 16).

The 'command and control' approach to computing plays out in the approach that is taken to ICT in schools. I can see this in my experience in schools. Shortly after I started to teach in my current school, a number of teachers on different occasions asked me if I had a key to the computer room yet, and laughed uproariously when I naively said that I had not. At the time I could not understand the joke. I have since come to understand the 'joke' and in many respects the joke is not funny. Access to the computer room was strictly controlled. Few students or indeed teachers had access to the computer room. The approach seemed to stem from a belief that computers were important valuable objects that had to be protected. I have come to understand this approach as a demonstration of power; those who had access to the computers were the possessors of power. Power was only given to those who could be trusted to maintain the status quo. I have detailed elsewhere my efforts to have a computer placed in the staff room to improve teachers' access to ICT (O'Neill 2002b: 126-8). After I submitted a proposal to make a computer available for teacher use outside of the classroom the Principal agreed that it was a good idea. But where we differed was on the question of 'Where will we put the computer?' My view was that the computer should be placed in the staffroom where teachers would have easy access. The Principal's view was that it should be in the library.

This sounds like a simple question of location but I believe there are deeper questions here. The principal was operating out of a different form of logic to mine. I was operating on the basis that if you want to encourage people to do something then you must try to remove the obstacles. He was working on the basis that if teachers really wanted to use the computer they would get over the obstacles. I was working on the basis that everyone has a right to access. His view was that access is a privilege that must be earned. While I take issue with Jones *et al.*'s (1994) view of computing above, I share their view of the factors affecting equity of access. The four factors that are essential for access are connectivity, ubiquity, interconnectivity and equity. Providing a computer for teachers' access in the staff room was addressing these factors. Connectivity was provided by giving access to the school network and Internet. Placing the computer in the staff room was a small step toward ubiquity. Ubiquity suggests that the technology should be everywhere. It should be wherever you need it. So it does not become an aside to your work or an addition to your work but a central part of your work, available for you to draw upon it when you need it or want it. I am suggesting that it should be a little like a pen. Sometimes you may have to go looking for one but generally when you need one there is one to hand. But I don't see the world as pen-determined. There are many useful and interesting things that you can do without a pen! While the pen is deterministic in that it is used mainly for writing, it does not determine what you write or where you write. Some students have discovered that using a pen as a pea-shooter is one of the oppositional uses for pens most frowned upon in schools! In Jones *et al.*'s (1994) terms, interconnectivity is the connectivity between people that underlies collaborative work. So while Jones *et al.* refer to collaborative work among teachers and students, I see this more as collaborative work among learners. Placing the computer in the staff room places it where it can support 'group learning, cooperation, and a sense of social responsibility among learners' (Jones *et al.* 1995: 17). Placing it in the library tends to support 'individualised learning, competition, and personal autonomy' (Postman 1995: 17). When Postman condemns the use of computers in schools I believe his vision is of the latter. He appears not to have conceived of the former approach. In my view if there is to be ubiquity then there should be a computer in the staff room and the library. At the time of my debate with the principal scarcity of resources gave the discussion a sharper edge. If only one computer was available in the short term where should it go? My position was that the objective should be to provide ubiquity and placing it in the staff room was our best attempt at ubiquity.

Deterministic approaches to technology tend to result in one of two approaches in the classroom. The sceptics' view leads to an approach that computers have no place in the classroom (Postman 1995). The evangelists' approach often indulges the cult of efficiency (Callahan 1962) and follows Skinner who suggested 'teaching machines and programmed instruction would enable students to learn twice as much with the same effort' (Skinner 1954: 94).

Skinner's approach can be seen in many school programmes that teach 'computer skills'. Programmes like the European Computer Driving Licence (ECDL) and Microsoft Office Skills (MOS) when presented in schools often take this approach. While behaviourist in stance, they are also technicist; focussing on providing students with decontextualised technical skills. The focus is on whether you have the technical skills to use a particular piece of software and/or hardware rather than what you might use it for. Computer

Assisted Learning (CAL) programmes take a similar approach. While the content is often based on curricular material the approach is distinctly behaviourist, focussing on efficiency. This type of computing contributes to a style of learning which is frequently limiting for teachers and learners.

The two sides of the technology argument, evangelism and scepticism, share a common base. Both are grounded in 'technological determinism', a term apparently coined by the economist and sociologist Thornstein Veblen (Chandler 1995; Ellul 1964: xviii; Jones 1990: 210). Technological determinism places technology as the prime mover in history, and sees society and culture as being totally determined by technology for good or ill. The position presented by Postman (1995) draws on the work of the media theorist Marshall McLuhan, who claimed that communications technologies such as television, radio, printing and writing profoundly transformed society. His claim that 'the medium is the message' illustrates his belief in the profound change wrought by technologies (McLuhan 2001: 7).

However, such a reified approach is not confined to media analysts and pop culture. Heidegger argued that the 'technological age can be defined by the structural loss of the autonomy of the subject and by the subordination of both subject and object to the demands of the network' (Heidegger 1977: 16–17). My understanding of what Heidegger is saying is that what appears in the technological age is no longer autonomous subjects over objects, but subjects and objects who become resources engaged in networks of optimization (Belu 2005: 577). Heidegger dismisses technology's putative neutrality and presents a 'dystopian' view of technology. In this new technological enframing, Heidegger sees 'meanings' destroyed and humankind's ability to recognize the potential of nature as a process of unfolding and revealing possibilities of living as gone and irretrievable. There are no criteria for the transformation of modern technology anywhere in Heidegger (Feenberg 2000: 226). Marcuse (1964: 158) recognised the capacity of technology for domination, claiming that, 'Today, domination perpetuates and extends itself not only through technology but *as* technology, and the latter provides the great legitimation of the expanding political power, which absorbs all spheres of culture.' He offers an account whereby humans' existence can be understood as 'ontology of action' (Farnum 2006). Once humans realize that our activities produce our current horizon of being, we can recognize that the 'chains' of our social structures are self-imposed. Marcuse was making a significant departure from determinism, placing action at the centre of people's potential. He concluded that science and technology need to be reformed at the most fundamental level, the level of technological rationality itself. He wrote:

> Freedom indeed depends largely on technical progress, on the advancement of science. But this fact easily obscures the essential precondition: in order to become vehicles of freedom, science and technology would have to change their present direction and goals; they would have to be reconstructed in accord with a new sensibility to the demands of the life instincts. Then one could speak of a technology of liberation, product of a scientific imagination free to project and design the forms of a human universe without exploitation and toil.
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> (Marcuse 1964: 19).

The use of the term 'technology' is part of the reification of technologies where 'technology' becomes a thing which has a life of its own independent of people, and people are frequently dominated by the reified 'technology'. Marcuse opened up the possibility of technologies of liberation sensitive to human imagination. Feenberg (1991; 1995; 1999; 2002; 2003; 2004; 2005) recognises the two opposing positions on technology which have so much in common.

> The Ruskins, the Heideggers deplored the dehumanizing advance of the machine while democrats and socialists cheered on the engineers, heroic conquerors of nature. However, all agreed that technology was an autonomous force separate from society, a kind of second nature impinging on social life from the alien realm of reason in which science too finds its source. For good or ill, technology's *essence* – rational control, efficiency – ruled modern life.
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> (Feenberg 1999: 1)

He compares the deterministic view of technology with the deterministic view of economic markets where the economy has been treated as a quasi-natural system with laws as rigid as the movement of the planets. He points out that an ideological battle had to be fought to establish the social nature of exchange and says the time has come for an anti-essentialist philosophy of technology. The involvement of ordinary people with technologies is more complex than the efficiency-oriented approach in much critique. Ordinary people encounter technology as a dimension of their life world. They strive to appropriate the technologies with which they are involved and adapt them to the meanings that illuminate their lives. Their relation to technology is thus far more complex than that of dominant actors.

In my view, the technology determinists, both evangelist and sceptics, focus too much on the technology itself and too little on what can be done or not done with it. They appear not to see that what can be achieved with technology depends on the context and the human purposes of those using it (Bromley 1998: 4-5). While challenging technological determinism, it is important not to fall into the trap of seeing computers as a neutral tool. All tools have propensities toward some uses rather than others. However a tool's propensities are not deterministic. It is possible to use tools in ways that were not originally intended. I have referred to Apple's position regarding the use of objects in 'oppositional ways' (Apple 2003: 14). The origin of the computer within the military with 'command and control' built in does not determine how it is going to be used in a classroom, provided we critically examine the context and the power relations that exist there. Postman's criticisms, O'Dwyer's analysis and Hawkridge's rationales all make a contribution to understanding technology, but they offer little recognition of the life-affirming potential of technologies, including ICT, and the possibilities provided by technologies to support original human agency. Each argument in its turn focuses on the potential for ICT to enable people to fit into structures which are defined externally rather than supporting people through their agency to act to improve their lives. This raises the question: apart from the evangelists' view and the sceptics' view, is there a way to reconceptualise technologies, in general, and ICT, in particular, which is life-affirming and supportive of original human agency, and moves away from technological determinism?

Reconceptualising ICT

While the support for educational ICT has been widespread (Hawkridge *et al*. 1990; O'Dwyer 1998; European Union 1996; Government of Ireland 1997) and there has always been some opposition to the introduction of new technologies into schools (Oppenheimer 1997; 2005; Postman 1995), recently a new perspective has been developing. This perspective takes the view that the answer to the question, 'Is this enormous investment in computing technology a good idea?' is without a simple 'yes' or 'no' (Bromley and Apple 1998: 1). Rather than looking for a simple 'yes' or 'no' we need to ask a more finely grained question. Bromley and Apple (*ibid*) suggest that suitable questions might include, ‘Investment in what kind of educational computing?’ ‘A good idea for whom?’ ‘Under what conditions?’ They criticise the belief that we can deal with the new technologies in a purely instrumental way and advocate the view that technology is a social practice (*ibid:* 2). This thesis describes uses of technologies in schools which I believe is a ‘good idea’. It is a good idea because of its transformational quality and the contribution it can make to the formation of good societies through the exercise of individual and collective agency (McNiff and Whitehead 2005).

While using technologies within school and other organisations I am examining if ICT may have the potential to overcome the ‘congealing’ factors that are at play in my workplaces. Within these workplaces I can see and experience the same logics that underpin deterministic approaches to technologies. As noted earlier, discussions have taken place within my workplace where some colleagues felt there was no need for us to think about whether offering skills based courses like ECDL (European Computer Driving Licence) was a worthwhile thing to do. I believe these colleagues believed that there is no need to think about ‘what is it’ that we do in school. All we, as teachers, need to do is take whatever it is that is given and do it well. This appears to me to be a refusal to engage with theory and to regard teaching as an operational activity. McNiff and Whitehead (2005) pursue this idea; that teachers are regarded as implementers of policy and until teachers regard themselves as knowledge creators in their own right they will continue to be treated as implementers. Furlong (2000; 2004) claims that teachers are not prepared to equip themselves with a basic understanding of doing research and what is understood as generating knowledge. McNiff and Whitehead (2005) claim that teachers are encouraged to carry out research but not to generate their own theory.

If ‘context and the balance of power in the specific situation do count’ (Apple 2003: 14), can an engagement with theory provide an oppositional view of productivity tools which enable them to be used to support original human agency in contributing something unique to human experience? Can the most common office productivity tools like Word and Excel and PowerPoint be used in an oppositional way? While Computer Assisted Learning (CAL) systems tend to be deterministic and seek efficiency in learning, by contrast the underlying nature of the Internet is much more democratic. The structure of the Internet is under diffuse control – some would say it is not under anyone’s control and access to the internet is widespread. The ability to contribute to the content of the Internet is considerable. Once you can gain access to the Internet it gives access to information, it gives the capacity to communicate in ways that you do not have in a conventional classroom. Could the Internet provide me with the framework to explore ICT as political action? It seems to me the ideas underlying an emancipatory use of the Internet are congruent with living theories. Introducing the idea of ICT as political action provides a means toward reconceptualising educational theory.

As part of my process of reconceptualising ICT I have had to examine my scientific training and, in order to maintain my integrity, engage with ideas about the nature of science and technology and how this can accommodate the reconceptualisation of ICT. The deterministic approaches to technologies presented above are often presented as scientific approaches. If they are scientific approaches then it is the science of the seventeenth century grounded in Newtonian mechanics and Cartesian geometry. They are machine models where in order to understand the whole, you need to understand the parts, where fragmentation is the standard approach to understanding, where 'the process of division is a way of thinking about things' (Bohm 1995: 2); where knowledge is to be gained by standing outside as a neutral observer; and where systems operate by a process of cause and effect. But the sciences of the twentieth century are grounded in quantum theory, relativity, evolutionary processes, and ecology. The underlying currents are toward holism; understanding systems as living systems; where the relationship between the parts is more significant than the discrete parts; where unpredictability is the rule rather than the exception (Wheatley 1992: 9). Within this model of science, cause-and-effect evaporates, objectivity is elusive, and the myth of value free science is exposed. The work of twentieth century scientists has much to contribute to non-deterministic views of technology.

It seems that innovative scientists use leaps of imagination to make their discoveries and then verify (or validate) them by use of the scientific method. This idea is supported by Capra:

> These insights tend to come suddenly and, characteristically, not when sitting at a desk working out equations, but when relaxing, in the bath, during a walk in the woods, on the beach etc.
>
> (Capra 1992: 39).

An example of this can be found in the work of several creative scientists. The German chemist August Kekulé Von Stradonitz describes a dream where he saw carbon atoms dancing then holding hands to form a ring:

> …he related some years later that the vision of the benzene molecule came to him while he was riding on a bus and sunk into a reverie, half asleep. In his dream, chains of carbon atoms seemed to come alive and dance before his eyes, and then suddenly one coiled on itself like a snake. Kekulé awoke from the reverie with a start and could have cried "Eureka!" He had the solution: the benzene molecule is a ring.
>
> (Asimov 1987: 474).

He then (in 1865) formulated the resonating ring structure for Benzene that is the recognised structure accepted today.

But this type of account is not unique in scientific discovery. Similar accounts are related to the discovery of the double ring helical structure for DNA (de-oxyribonecleid acid) credited to Watson and Crick. While they undoubtedly carried out research it is not unreasonable to claim that Watson and Crick guessed the structure of DNA. Francis Crick, referring to the discovery, says*:*

> After many ups and downs, Jim and I guessed the correct structure…The key discovery was Jim's determination of the exact nature of the base pairs (A with T, G with C). He did this not by logic but by serendipity…In a sense Jim's discovery was luck.
>
> (Crick 1989: 64-65)

Asimov is less sympathetic. He suggests that their success was attributable to a photograph taken by Rosalind Franklin that they obtained by dubious means. Franklin was part of Maurice Wilkins' research team at King's College London.

> In 1953, the English physicist Francis Harry Compton Crick and his co-worker, the American biochemist (and one time Quiz Kid) James Dewey Watson, put all of the information together – making use of a key photograph taken by Franklin – without her permission – and came up with a revolutionary model of the nucleic-acid molecule.
>
> (Asimov 1987: 583)

While Franklin and Wilkins had carried out much patient research, this painstaking scientific work did not result in the actual discovery. Crick acknowledged Franklin's rigorous approach:

> Rosalind, in particular wanted to use her experimental data as fully as possible. I think she thought that to guess the structure by trying various models, using a minimum of experimental facts, was too flashy.
>
> (Crick 1989: 68)

The discoveries of Kekulé, Crick and Watson (Crick 1989) and others suggest that intuition and imagination have a significant part to play even in scientific innovation. I am addressing this matter at this point because I am looking for approaches to using, teaching and learning ICT that are not deterministic. By engaging with 20th century science rather than 17th century science, I find that science can offer approaches that are creative and innovative rather than restrictive and stultifying.

Heisenberg's early problem with electrons is an interesting one for us. He found the more he knew about the position of the electron, the less he knew about the speed because in order to measure the speed he had to change the position and the act of measuring in turn changed the speed.

> Heisenberg showed that there is no way of devising a method of pinpointing the position of a subatomic particle unless you are willing to be quite uncertain about its exact motion. And, in reverse, there is no way of pinpointing a particle's exact motion unless you are willing to be quite uncertain about its exact position. To calculate both exactly, at the same instant in time, is impossible.
>
> (Asimov 1987: 376)

This difficulty arises from the old scientific approach of breaking things into their component parts in order to learn more. However, the changing nature of quantum mechanics suggests we must see the whole in order to get the picture (Bohm 1992; Capra 1992; Wheatley 1992).

This discussion of the features of twentieth-century science is important. The theories of Relativity and Quantum Mechanics completely change the physicist's view of the world. All the certainty and predictability of physics began to disappear and many conclusions are based on probability. This fundamental change in physics was followed by similar changes in the other sciences. In chemistry, the Second Law of Thermodynamics indicated that the universe (and any other system left to its devices) was moving in a direction of increasing disorder but, fortunately for us, this process was moving slowly so we did not need to worry for the moment (Asimov 1987: 367). However, studies in ecology indicate that when systems are left to their own devices they become more complex, not less so. A wasteland left alone over a period of time will start growing plants and supporting animals, and eventually become woodland. This is a process called succession (Roberts 1977). The study of evolution indicates that systems, instead of becoming more disorderly, in fact increase in orderliness and complexity over a long period of time (Darwin 1859; Kimball 1975).

Mathematics has been concerned mainly with linear equations. With small changes in inputs, these equations produce small changes in outputs. However during this century, interest has been increasing in complex equations where small inputs can produce large and unpredictable outputs. This has given rise to the odd notion of fractional dimensions or fractals (Gleick 1994: 98). These features of twentieth-century science are important because they indicate that we live in a world that is not simple or predictable and where there is order in apparent disorder (Bohm 1995: 111-156). These new paradigms in science have parallels in educational research (Benson and Hunter 1993; Blair 1993; Ennis 1992; Griffiths *et al*. 1991; Rasmussen and Mathiasen 2004; Wheatley 1999). McNiff uses the language of chaos theory when she says action in educational research may be seen as '…a dissipative structure, a bifurcation point which offers multiple possibilities of potential, each one of which could lead to the creation of a new universe' (McNiff 2000: 20).

The discussion of ideas arising from what some call the 'New Science' (Wheatley 1992) suggests an approach to the use of ICT that is participatory for all those involved. Such an approach moves away from the propositional logics of unambiguous lines and binary divides and from practices of imperialism and domination (Whitehead and McNiff 2006: 35-6). This suggests a need for new practices that move away from deterministic approaches to technologies and in particular ICT. They are practices which include blurring the division between teacher and students and recognising all who participate in an educational enterprise as learners and knowers. The practices move from closed modes of thinking to living logics. They are the kinds of logics that see the potentials in everything and see everything in relation with everything else (*ibid:* 39). They are not logics which abandon the past but which are inclusional in the sense that they include propositional and dialectical forms of thinking as a sub-set. '…one may expect the unending development of new forms of insight, which will, however, assimilate certain key features of the older forms as simplifications, in the way that relativity theory does with Newtonian theory' (Bohm 1995). The changing nature of quantum mechanics suggests we must see the whole in order to get the picture (Bohm 1992; Capra 1992; Wheatley 1992).

This account has been a theoretical analysis of how ICT is conceptualised and how it might be reconceptualised. As this work is based on building a living theory of practice I would like to draw on my practice to give a short narrative of what this work might look like. As before, I draw on Arendt's conception of political action in terms of labour, work, and action (Arendt 1958), and Habermas's (1975) ideas of communicative action to underpin the theoretical basis of this work.

World Wrestling Entertainment and Communicative Action

When I read Habermas (1975; 1979; 1984; 1987), Gadamer (1979), Buber (1958) and others who speak of dialogue I see civil, civilised people who sit together and communicate with one another. I see that this could be relevant, say in higher education, where there are people who get involved in a certain level of discourse. When I speak of dialogue I am not talking about something as elevated as that. I am talking of people communicating in simple ways, sometimes not even communicating in words. Within the activities described in this thesis there are projects where students are working with technologies where an ideal speech situation is hard to identify. One of these activities involved students getting involved with ICT projects where they build web sites. As part of the process of allowing students to take control of their learning, the students choose what the subject matter of their web site will be. This can be a risky matter for the teacher as students may choose to design and develop their web sites around topics that are not elevating.

As I described earlier, one student decided to build a web site on 'World Wrestling Entertainment'. My internal reaction was, 'A web site of over-weight, half-naked men – that's just what I need!' However I curbed my tendency to take control and let him proceed with his choice. Keith developed the web site, maintained a reflective diary while he developed it and wrote a report at the end. In his report on the work of his project Keith wrote what he learned from doing the project. He wrote about different elements of his learning. He explained that he had learned about World Wrestling Entertainment: he learned the names of various wrestlers who won various championships; he learned who won most often, who was the heaviest weight and so on. Keith also explained about the ICT skills he had learned. He learned how to build a web site. He learned how to download images form the internet; he explained how he could insert those images, how he could add text and how he could insert hyperlinks. He also demonstrated his self-reflection. He reported how he learned things about himself; he learned that he was better at computers than he thought he was. In his report he said, 'I used to think I was no use at computers, now I think I am quite good. I think computers might be useful to me in the future.' (Fallon 2002: 2)

My reflection on this is that we have come a long way from World Wrestling Entertainment to the point where Keith is writing these things. He is explaining articulately what he has learned and how he has learned as part of this project. He is analysing his learning at various levels. First, he is saying that he has acquired new information. These are the details of the wrestlers and their participation in competition. Second he has gained skills. That is how I would see the ability to download images from the internet. But he has gone further. He has articulated clearly that he has learned, at the level of information, at the level of technical skills and at the level of self-awareness. He has a sense of pride in what he has done. The key focus of the proponents and opponents of technology is on acquisition of information and sometimes on technical skills. This young person has used ICT to go much further. If we examine his project, it involves labour, work and action (Arendt 1958). Arendt refers to labour as 'routine behaviour required to meet basic needs'. Downloading the images of wrestlers could be seen as 'labour'. Work includes activity by artists and craftspeople to make lasting objects that comprise the human world. The creativity of designing and building the website was Keith's work. Action requires collective interaction to determine what is good and just. Keith's work on the website through interaction with fellow learners enabled him to take control of his learning, which is an aspect of taking control of his life. This can be seen as political action.

Reconceptualising ICT as political action is about devising ways of using ICT and other technologies that are not deterministic, colonising, dominating nor imperialistic but are life-affirming. Reconceptualising ICT involves living logics (Whitehead and McNiff 2006). The ideas of the inherent capacity of all living things to generate and transform is present in the new science and in the work of McNiff (1984; 2000; 2005; 2006) and others. Despite its origins, ICT can take a form that supports human agency, enables generative transformation and is life affirming. Such an approach will draw on the work of the 'New Science' (Bohm 1995; Capra 1992; Gleick 1994; Wheatley 1992) as a source of scientific thought which is not deterministic. It will draw on Bromley (1998) and Feenberg (1991; 1995; 1999; 2002; 2003; 2004; 2005) for an approach to technologies as a social practice. Whitehead (1989; 1993; 1998; 2003a; 2004; 2005) and McNiff (1984; 2000; 2005; 2006) provide a theoretical underpinning in their ideas of generative transformation and living theories approach. Farren (2006) has started an approach to ICT as a social practice in Ireland, and this will add to the body of knowledge.

I now give an account of the actions I took to encourage a view of ICT as political action.