

Integration or transformation?

*A cross-national study of information and communication technology in
school education*

by

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Abstract

The advent of relatively cheap micro-computers in the 1980s has led to major investment in information and communication technology (ICT) for schools. The technology has been developed continually, creating a situation where there may be significant differences between policy and practice. The literature relating to innovation diffusion and the rationale for ICT in school education has concentrated upon effectiveness and teacher professional development. Existing models of development in the area are limited in scope or make ill-founded assumptions. Little work has been done on the question of alignment between policy and practice.

This study used a grounded theory approach to examine the relationships between policy, implementation and underlying models of development. This was done through a process of policy comparison, consultation with experts in the field and case study observations. The methodology used a comparative case study approach at national, school and classroom levels and examined issues such as the nature of development processes for policy in the area, implementation and practice in the use of computers in classrooms, teacher professional development and stages of development as perceived by practitioners. Data were gathered from the United States of America, England, Estonia and Australia from November 1999 to September 2002.

The study found ICT curriculum approaches for students were strongly aligned with a stage of development which emphasised the integration of ICT into existing curricula and current classroom practice. There was poor alignment between overlapping policies for teacher training and student learning outcomes and also between policy and classroom practice. It was confirmed that students generally have better access to computers outside school than within it, a situation largely ignored by policy. It was also found that experts in the field perceived increasing reliance upon generic office software as an outmoded 'tool' approach, and saw ICT as a 'driver' for transformative change in school education. School and classroom observations confirmed that local practice included transformative uses of ICT.

From these findings a general model of stages of development was derived. The model consisted of an introductory Phase 1, where students in school first use computers and information technology becomes a subject choice; an integrative Phase 2, where information and communication technologies are used to enhance learning opportunities in all traditional curriculum subject areas; and a transformative Phase 3, where the curriculum clearly includes topics of study that would not exist without information and communication technologies and schooling for most students no longer fits the traditional group-instruction model.

The model has implications for alignment in policy development based upon a national cross-curriculum framework. It demonstrates the importance for teacher professional development to include training in virtual teaching and the evaluation of digital materials. In particular, there is a need to examine the alignment between conventional learning outcomes, policy and practice when ICT is much more available to students outside school than within.

The study provides guidance for future policies concerning teacher ICT professional development and argues for their alignment with national cross-curriculum frameworks for ICT in school education. It will also be useful for educators training pre-service teachers to use and prepare online digital learning materials. Further, the study also informs school communities about the need to use ICT as a way of linking their institution with student homes and to extend learning opportunities.

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Glossary and acronyms

ABS	Australian Bureau of Statistics
ACCE	Australian Council for Computers in Education
ACOT	Apple Classrooms of Tomorrow
ACSA	Australian Curriculum Studies Association
AEC	Australian Education Council
ALTP	Arizona Learning Technology Partnership
Bandwidth	The communication capacity of a link between computers: measured in bits per second
Becta	British Education Communications and Technology Agency
Bit	Binary Digit: the smallest piece of data stored in a digital computer system
Broadband	Technically, a communication link which carries more than one kind of data at a time. Common usage for a link with bandwidth greater than 200 kbits/second in each direction
Byte	Sufficient bits to store a letter of the alphabet or similar character: generally 8 bits
CAD/CAM	Computer Aided Design/Computer Aided Manufacture
CARTS	Computerised Assessment Recording and Time-tabling System (Tasmania)
Computer	A universal machine for processing information
DETYA	Department of Education, Training and Youth Affairs (Commonwealth of Australia)
EC	European Community/European Commission
ECDL	<i>see</i> ICDL
EdNA	Education Network Australia
ERIC	Educational Resources Information Center (Syracuse University/Federal Department of Education, USA)
EU	European Union
FBI	Federal Bureau of Investigation (USA)
GCSE	General Certificate of Secondary Education (UK)
Hardware	Equipment comprising and associated with a computer system
HMI	Her Majesty's Inspectorate
IBM PC	International Business Machines Personal Computer or a clone thereof
ICDL/ECDL	International (European) Computer Driving Licence
ICT	Information and Communication Technology/ies
IEA	International Association for the Evaluation of Educational Achievement
ILS	Independent Learning System
INSET	In-service education and training
Internet	A network comprising connected computers around the world
IRT	In-school resource teacher (Tasmania, Australia)
ISTE	International Society for Technology in Education (USA)
IT	Information Technology
ITEC	Information Technology in Education and Children (UNESCO)
KEDI	Korean Educational Development Institute

KITO	Key Information Technology Outcomes (Australia)
KLAs	Key Learning Areas (Australia)
LCD	Liquid Crystal Display
MCEETYA	Ministerial Council on Education, Employment, Training and Youth Affairs (Australia)
MEP	Micro-Electronics Education Programme (UK)
MESU	Micro-electronics Education Support Unit
MOO	Multi-User Object-Oriented (a kind of multi-user role-playing environment)
NCATE	National Council for Accreditation of Teacher Education (USA)
NCES	National Center for Educational Statistics (USA)
NCET	National Council for Educational Technology (UK)
NCREL	North Central Regional Educational Laboratory (USA)
NCVQ	National Council for Vocational Qualifications (UK)
NETS	National Educational Technology Standards (USA)
NOIE	National Office for the Information Economy (Australia)
NSW DET	New South Wales Department of Education and Training
NSW HSC	New South Wales Higher School Certificate
OECD	Organisation for Economic Co-operation and Development
OFSTED	Office for Standards in Education (UK)
OHP	Over-Head Projector
PD	Professional Development
PHARE	Poland and Hungary: Action for the Restructuring of the Economy (EC)
PHARE-ISE	PHARE (see above) Information Systems in Education program
QCA	Qualifications and Curriculum Authority (England)
QUANGO	Quasi-autonomous non-governmental organisation
SACS	School Administration Computer System (Tasmania)
SCAA	School Curriculum and Assessment Authority (UK)
SITES	Second Information Technology in Education Study
Software	Instructions and data controlling the behaviour of a computer
TEFA	Technology Education Federation of Australia
TILT	Technology in Learning and Teaching (New South Wales, Australia)
TIMSS	Third International Mathematics and Science Study (IEA)
TLCF	Technology Literacy Challenge Fund
TLITE	Teaching and Learning in an Information Technology Environment (Canada)
TTA	Teacher Training Agency (UK)
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA or US	United States of America
UWS	University of Western Sydney
VET	Vocational Education and Training (Australia)
V-LAN	Virtual local area network
WebCT	Web Course Tools (commercial company)
WGU	Western Governors University (USA)
World wide web	Inter-linked information in hyper-text format on some internet computers
YCCI	Young Children's Computer Inventory Project

Chapter 1 Introduction and the research problem

1.1 Introduction

This thesis emerged from the author's involvement in change management and technology initiatives over a period of some twenty years. Related activities included working as an apprentice in a high technology avionics firm and a teaching career that started by restoring electric light to teachers' houses in Nigeria shortly after the Biafran conflict in 1977. Innovations were diffused into that local community when students were taught to use slide rules mass-produced on the spirit duplicator; and by a class trip which took students to see the nearest computer at the University 90km away. Observations during this period affirmed the potential of technology to transform lives, and the importance of appropriate technology. When a Nigerian colleague teacher was asked why their culture had been overrun by Western values in scarcely less than a century (Achebe, 1958), the reply was this: "When we saw the first white man on a bicycle, we knew we were defeated."

This speaker expressed the opinion passed through an oral tradition dating back to the Berlin conference of 1885, when Africa was partitioned and missionaries started to arrive (Collins, 1997). The level of technology required to produce a bicycle was perceived as so advanced, there was no point in offering resistance to the ideas it represented. Subsequent post-colonial education was conducted in English under the auspices of a British accreditation scheme. Despite this appropriation, much local culture, language and social mores had survived alongside the elements introduced from Europe. This example of technology-based cultural transfer gives rise to a useful thought experiment. If a member of a group not previously contacted by any technologically advanced culture was to see an airliner fly overhead, what possible basis for decision-making would he or she have in determining whether to adopt ideas or resources from its makers? What would be the ethics of such a situation, both from the developers' and the potential adopters' points of view? Taking another example, how could one choose to adopt a new source of energy and its associated distribution

system such as electricity¹, and consciously balance its power to communicate, do physical work and entertain against the probability that members of societies using it tend to have less extended family members nearby, to suffer diseases like obesity and so on? To put it in a nutshell, there is a real problem associated with choosing future paths of technology adoption even when many of the consequences are known. Answers to these important questions have hitherto fallen into two main categories: that the technology itself determines its trajectory (Bijker and Law, 1992, p. 17), and that innovations are adopted through a process of social assimilation networking (Rogers, 1995, p. xvii).

A similar challenging choice faces teachers in relation to the introduction and systemic adoption of information and communication technology (ICT) in schools. It is their professional task to understand, anticipate, assimilate and grapple with the enormous changes in their working lives that ICT implies. Yet the consequences for themselves, their students, and the mutual relationship between both groups have yet to be fully understood. Some pioneer teachers see ICT as a tool which can help them respond to accountability requirements for individualising learning in the continuing context of a mass-instruction, classroom-based education system. Other teachers can be described as ‘laggards’, who resist it for a number of reasons, such as unreliability, lack of training, or inappropriateness for the subject or sector. The pioneers as agents of change are generally associated with the societal transformations which are the consequences of new technology. Although they may not have personally invented this technology, they are often regarded as being responsible for the innovation they champion. Once a change, such as the transition from text-based to multi-media scholarship has been implemented, it can become institutionalised, reversed or, occasionally, built upon. The process of change can also be a time of tension, for both the change-agent and the society affected.

Hence questions that prompted this study included: what are the factors that influence such changes? Can we forecast the implications, consequences and directions of

¹ See an excellent example of the consequences of electrification in Akrich (1997, p. 216). Village property in the Ivory Coast used to be collectively owned, with the elders allocating tracts of land over periods to individuals on the basis of need. Electrification implied more permanent allocations of land than theretofore, and brought about a distinction between public and private property. In so doing, it brought about a new system by which the State and individuals related, and even universalised taxation in a region where only a small minority earned income.

innovation adoption, even in a restricted context such as ICT in education? What are the parameters which determine the current direction of information technology in education, and can any predictions be made about probable outcomes for the next decade?

1.2 Background

Computers represent an innovation for school education. Hence general theories of innovation diffusion are helpful in understanding the critical elements determining how these can succeed or fail to be adopted. Since school education is a largely government-run or legislated activity, the role of bureaucracy in determining policy objectives for school education is a potentially significant factor. A distinction can be drawn between those countries which enforce a central policy framework on schools and those that allow greater diversity and more local determination of school policies. This is particularly significant in the area of innovation diffusion, where larger centralised systems can mandate rapid sweeping change or sustain greater inertia. The extent to which an organisational culture or governance system will promote an innovation relates to the nature and effectiveness of the innovation itself. Therefore a review of pre-conditions for information and communication technology to be effective and its potential for radical transformation was undertaken.

1.2.1 Innovation diffusion

Change is a normal part of life, and as much a feature of the educational landscape as any other area of society (Haddad & Draxler, 2002, p. 202). The response of individuals to change depends upon many factors, some of the most important being the perceived effect of the change, their degree of control over the change and attitudes formed concerning its nature. Extensive research literature and practical evidence is available describing the innovation diffusion process in a wide range of fields (Clarke, 2001), and this can be referenced to identify likely critical factors and general trends. In addition there is ample experience of change processes within school education. Examples include the transition from Piagetian to Vygotskian theories of pedagogy (Dunne, 1997; Masquod, 2001), the rise of generic competency

frameworks (Mayer, 1992; Sanguinetti, 2003) and current trends to re-organise school education from discipline-based structures to new essential learnings (Luke, 1999). ICT is not the first technological innovation to be applied to school education: blackboards, biros and television have all been new introductions in the past (Kessell, 2001). Applying the lessons of these previous experiences to the specific instance of ICT in school education is slightly more problematic, since there is a diversity of experiences and contexts to consider. It will be important to consider the values and expectations of policy makers involved, as well as the implementation phases and communication channels used to communicate policy to practitioners. Particular special features of ICT into school education are the swift rate of change of the underlying technologies and the social context into which the innovation is being applied.

1.2.2 Centralisation or devolution of responsibility for education

Generally, national governments devolve certain powers and responsibilities to more local area control. The degree of devolution generally depends upon historical precedent, the policy area concerned and other local factors. For example, the USA and Australia both operate as a federation of highly autonomous states and education is constitutionally a state responsibility in these countries. However, in France, education is taken as a national responsibility and is organised on that basis (Kontogiannopoulou-Polydorides, 1996, p. 64).

Most countries are responding to the implications of information technology in education, but the nature of these responses is shaped by the relative degrees of centralisation and devolution, cultural mores, relative affluence and other factors. It has been suggested that a centralised education system has curriculum policy determined on a national basis by a politico-administrative elite (Lwin, 1997). Decisions are taken centrally, and disseminated to schools. Sometimes there is an enforcement mechanism, which may involve a national inspectorate, or may link achievement of specified outcomes to some degree of funding. With high centralisation, it is possible to generalise with some confidence about the nature of the education system (Guijarro, 1999, p. 63).

Decentralised systems have policies that emanate from more local, state, regional or community control of schools. Examples of decentralised systems include the USA, Canada, Germany, Australia and India. Schools can have funding and associated policy pressures from a mixture of legislative levels within the country, and these can change proportionately over time. Some regions have centralised curriculum control, but decentralised financial support. For example, the region of Bavaria in Germany centrally approves curriculum guidelines for all subjects in schools, in contrast to the rest of the country where teachers have greater autonomy. England had a cooperative partnership between national and local authorities until the Education Reform Act of 1988 when the central national government nearly eliminated the influence of regionally based administrations.

The context of this study therefore included the complexities of political control over schools, responses to technological innovation and the interaction between these two areas.

1.2.3 The potential of information technology for radical transformation of school education

Through studying history, one may better understand the present; understanding the present may help us to determine the future (Furay & Salevouris, 2000). The professional evolution of doctors and teachers over the past hundred years has often been compared (Papert, 1993, p. 1). A century ago, the teacher typically worked with a large class of students, with anything from 30 to 100 children, and used a display device such as a blackboard to communicate visually with them. Modern teachers operate in very similar conditions with a class of 20 to 30 students, perhaps a whiteboard rather than a blackboard, but in the main using similar techniques to his or her predecessor. Student-based learning and collaborative groups emerging from constructivist approaches might be the most significant recent change in teaching. The doctor on the other hand, is more likely to be a member of a multi-disciplinary team which can utilise equipment costing millions of dollars. On the surface there appear to be significant differences in the evolution of the two professions, with medical specialisation and scientifically developed equipment playing a major role in the field

of health care. There may be some merit in examining educational contexts where more technology has been used and greater staff heterogeneity is evident to see if there have been associated improvements in learning and/or greater individualisation.

There are some signs of a trend to multi-disciplinary teams and more extensive use of technology in education. Technology has the potential to change the way professionals carry out their responsibilities in any field. In the case of teaching, and learning, either the level of technological penetration has not yet reached a critical depth, or we have not yet found effective ways to improve the process with the tools at hand. It is possible the learning process may be improved by the injection of a considerable capital equipment investment, but it has not yet been demonstrated this can be as effective as in the healthcare industry. There are some signs that the education business is becoming more disparate, and workers in the field are not necessarily homogeneously qualified in identical disciplines, as the following examples suggest. Where children with special needs are integrated into the mainstream classroom, it is quite common for individual children to be supported by an aide to meet their learning needs by working alongside the teacher. This growth in teacher aides, along with the differentiation of additional skills in the school, is on the increase (Vinson, 2002, 43:Chap. 9). Teacher librarians are in some ways teachers with a particular disciplinary skill. Some schools are recognising that they need to employ specialists in information technology support and management.

For instance, a prominent independent school in Hobart, Tasmania advertised a 'Network and Computer Resources Manager' position (Farrall, 2000). The responsibilities of the senior position included year-round 24 hour maintenance of the ICT infrastructure and curriculum implementation of learning programs within flexible working hours. This was in the context of a school where each of the 1,159 students carried a personal laptop computer supported by a team of six IT professionals. This growth in combined technical and educational staff had occurred relatively quickly, over a period of 10 years.

This growth in information technology management in many schools mirrors changes that have been taking place in industry over the previous decade. As firms participate

in the information revolution, their boards are realising that the Chief Executive Officer requires a Chief Information Officer. Where computers have become embedded in a business, shareholders and executives have understood that efficient operation of IT is vital to business profitability and sustainability. Also, there has been a realisation that information technology gives an opportunity to radically transform business processes, and this is particularly evident in the current growth of e-commerce and dot.com companies. These non-traditional companies have operations that differ very greatly from those of their traditional competitors. A traditional appliance vending company might require a distribution network of retailing outlets in local high streets with highly presentable premises. However, a single room of computer servers and a very large remote warehouse is all that an Internet company may require to achieve the same volume of sales. With marginal costs, and very few staff, the latter company can be highly competitive.

Business processes re-engineering has been a catch-cry for information professionals working in the business, commercial and government sectors for the past decade. This realisation that the way in which business is done can be radically transformed by the appropriate application of information technology has led to the transformation of many adaptable traditional institutions. Many stock exchanges no longer have a trading floor, because telecommunications and computer based trading have replaced the problematic and stressful human inter-changes that have traditionally been the main way of doing their business.

In educational circles, perhaps the nearest equivalent to business process re-engineering has been the swing from determinism and Piagetian stages of development, to Vygotskian constructivist learning approaches (Lock, 1996). Many proponents of information and communication technologies in education espouse the linkage between ICT and a constructivist learning approach. They detail the ability of the machines to individualise education, and to validate existing constructs before scaffolding the emergence of new ones. Therefore the development and control of ICT in some schools has become more than a service function, moving into a central position of power within the administrative hierarchy of schools. This has happened in a relatively short period of time, considering the constraints on educational systems

and that only 20 years have elapsed since the first personal computers were manufactured.

One of the issues addressed in this thesis is the potential for radical change in the education sector following the current technology diffusion period. There appear to be significant differences in the responses of business and education to the same innovation – ICT. Many businesses have been made more efficient and even transformed through the adoption of IT. However, school education has not adopted ICT to anything like the same extent, and there are few surface signs of improved efficiency or transformation. This is only one of the problems to be examined. Its investigation requires an historical understanding of appropriate technologies, of technology transfer and of cultural appropriation.

1.3 Context

As global communications and transport have improved over the last century, issues that affect one country soon begin to affect others. Disease, knowledge and trade flow continuously around the world, and there is a sense of a global market and a global community. ‘Megatrends’ are bottom-up forces that propel changes in society (Fong & Naisbitt, 2000). These megatrends include globalisation - the idea that we live in one world both ecologically and economically. Global competition is a stimulant for the process of continuous change and is particularly important in the areas of education and research. Education at all levels has been affected by these megatrends because more knowledgeable workers can carry out more efficient production (Australian Manufacturing Workers Union, 1999, p.36). Also, the creation of new knowledge becomes more important because new ways of doing things can be more efficient. Innovation propelled by competition and technological advancement has therefore become an important part of modern life, with lifelong learning one of the consequences in everyday living. Recent expansions of market sizes and the speed of modern communication/transport systems have vastly increased the pace of change.

Moseley (1995) wrote of the influence of megatrends on higher education, and included less money, more accountability and increased use of new technology as

significant trends of which planners needed to be aware. Computers, like teaching machines before them, have been expected to change education radically but until now such change has mostly been restricted to tertiary education. Only recently have personal computers been developed with the capacity to handle video, sound and other media to the extent necessary to engage learners. Simultaneously, global connectivity through the Internet has become widely available, and this appears to facilitate crucial links between teachers and learners (Mwagiru, 2001).

These developments have increased interest in the role of ICT in school education. This interest has focused upon preparing students for employment in a globally competitive environment predicated upon the widespread use of information technology, and on the general use of ICT to improve educational outcomes. There has been debate about which of these focus areas should be more important.

During this study, the first of these focus areas was the subject of an Australian Federal Government limited request to tender for the development of:

key performance measures to monitor progress in the information technology knowledge and skills of Australian schools students to be used for the reporting of nationally comparable outcomes of schools within the context of the 'National Goals for Schooling in the Twenty-First Century' (DETYA, 1999b).

The terms of reference for the tender restricted the investigation to IT career oriented skills and training. Members of the appointed research team agreed the focus ought to have been on the cross-curriculum use of computers to enhance learning (Stokes, 2000).

This restriction appeared to derive from the wording of the *Adelaide Declaration on National Goals for Schooling in the Twenty-First Century*, the second such national declaration (MCEETYA, 1999, 1.6). While this reaffirmed the eight main areas of the curriculum established by its predecessor, information technology was referred to separately as a goal:

In particular, when students leave school, they should: ...

1.6 be confident, creative and productive users of new technologies, particularly information and communication technologies, and understand the impact of those technologies on society.

After the letting of this tender, a subsequent project opened up the field to consider the broader implications of computers in education. The statement of requirement specified a project to “undertake a detailed examination of existing models of teacher pre-service education and in-service professional development to facilitate the integration of new technologies into classroom practice” (DETYA, 2000). This significant activity in educational administration circles gave further impetus to the study.

1.4 Problems of language

An initial step in studying specific matters concerning the use of ICT in school education is addressing the issue of terminology and language. When using terms in an international context, it became apparent that similar terminology is used with different intent and meaning from country to country, even those sharing a common language. These differences were largely due to historical precedence and relative political power of different lobbies within the various educational systems. In order to make meaningful comparisons between such systems, the issue of terminology is now discussed.

1.4.1 The meaning of ‘technology’

The term ‘information technology’ (IT) is sometimes used to describe the use of personal microcomputers in the hands of school students. This term is rapidly being superseded by the term ‘information and communications technology’ (ICT), reflecting the common understanding that a computer’s potential is significantly enhanced by connection to a local network, and even more so by connection to the Internet. This new descriptive phrase also recognises the convergence of information and communication technologies, where appliances for computation and those for communication contain similar components and are increasingly capable of providing both sorts of facility to people using them. The term ‘ICT’ is generally used in this study, except in the case of direct citations.

While ICT is often used in the United Kingdom and other countries, the term ‘informatics’ has been widely used in the European context for some time (Plomp *et al.*, 1996, p. 7). This relates very much to an area of study, with an emphasis on information science or general information processing. It has given rise to a new term, ‘telematics’, to describe the combination of informatics and telecommunications. Such subject-specific terms are used in a more restricted sense than the present study is intended to cover.

The word ‘technology’ brings to mind different associations for different people. Following the Hobart Declaration on Schooling (Australian Education Council, 1989) Technology became one of the eight areas of the nationally developed curriculum in Australia. Since information technology as a topic had been largely omitted from the development and mapping phases of the various Australian states’ curriculum documents, this author and others suggested it be incorporated into the Technology area. The technology area is based around knowledge and process strands, which include ‘Design, Make, Appraise’ and ‘Materials’. By analogy with traditional technologies, information technology has been incorporated into this pattern by extending the conventional list of materials (such as wood, metal, plastic, flour, eggs, wool) to include data. Thus the process strand of ‘Design, Make, Appraise’ can apply to data-as-a-material to include systems analysis, programming and software evaluation.

Similarly, IT was initially incorporated within the ‘Design and Technology’ area of the United Kingdom national curriculum. The two terms IT and ‘technology’ have therefore been somewhat confused in educational circles. In an initial phase of this research a request for pupil standards documents in information technology was circulated to primary school principals in Tasmania. This generated as many competency lists for ‘technology’ as for IT. To resolve such misconceptions, in 1999 the Australian Council for Computers in Education produced a report on the development of Teacher Learning Technology Competencies (Williams & Price, 2000). This new phrase ‘Learning Technology’ was intended to stand for the use of computers and similar equipment in the teaching-learning relationship. At the time of writing, it was yet to be seen if this phraseology will be accepted more widely.

As a further complicating factor, the common terminology in the USA for describing computer use in schools is ‘educational technology’, while the hardware equipment involved is referred to as ‘the technology’. This is particularly evident when looking at publications from peak organisations such as the International Society for Technology in Education (ISTE) which is examined later in this study, under the analysis for the USA. A parallel group in the USA produced *Standards for technological literacy*, which relates particularly to skills in engineering, agriculture, manufacturing and construction (International Technology Education Association [ITEA], 2000). While ISTE concentrates on the use of computers to enhance education, ITEA’s work is concerned with a completely different sphere. This confusion has been carried into the terms ‘technological literacy’ (ITEA), and ‘technology literate students’ (ISTE).

The interpretation of the general terminology describing the field is now followed by an examination of some more specific terms within the area.

1.4.2 The meaning of ‘Computer Studies’, ‘Computer Literacy’ and ‘Computing across the Curriculum’

Computer Literacy is a relatively new term encompassing a broad range of student understandings and skills which some commentators argue children should have (Weber, 1997). Definitions of Computer Literacy go further than the mere acquisition of operational skills and include conceptual understandings of media as message (McLuhan, 1964) and validating information sources. By looking at the same information on a topic through a variety of media, including computer and Internet-based systems, students can determine its reliability and relevance (Quesada & Summers, 1998). Such a view of computer literacy aims to give it long-term validity by distancing it from the operational specifics and creating a meta-cognition level for its teaching in schools.

Computer Studies are generally accepted as study about computers, their operation, the implementation of computer systems to solve problems and the social consequences. Students in computer studies courses usually have an interest in the

field which may lead to employment in related areas. Vocational courses in web-site design, personal computer repair, and the operation of particular software applications would all come under this heading. Pre-tertiary courses in computer science or information systems would also fall into this category.

Computing across the Curriculum is a term which covers the more general use of computers by school students to assist learning in all subject areas. ICT can be used as a writing tool (through word processing) or as a visualisation tool when simulations are used to replicate dangerous or conceptually complex situations such as preferential electoral systems. This more general use of computers in education was the focus of this study, which was taken to encompass the other terms.

Each of these areas is reasonably distinct, but they share a common use of computers, albeit for different purposes. Within each area students will need to acquire specific operational skills, but these are generally subsidiary to the main learning purposes of the area. Among the challenges to providing these operational skills are the capital costs and rapid obsolescence of the necessary equipment.

Despite the confusion of terminologies, even within the same country, this study examined the use of computers for learning and teaching by students of school age, in all areas of the curriculum, and in all subjects taught to them. Since the methodology selected compares material from several countries where usage of these terms is very different, this thesis uses the acronym 'ICT' in the text generally, with direct quotes from source documents unchanged.

1.5 Research questions

Whether the key phrase used is computer literacy, technology literacy or computing across the curriculum, the objective of many national ICT programs is the integration of new technologies into education. It has been pointed out that this does not mean the intention was to teach the new technologies in all subject areas, but rather they are expected to facilitate teaching and learning in all those areas (Cornu, 1995). This facilitation can take place at the classroom level, with direct use of ICT by students,

and also at the systemic level. Examples of systemic approaches include the integration of evaluation into instruction, and management of transition difficulties such as those encountered when a student moves from class to class, teacher to teacher, school to school. At an inter-system level, technology raises the prospect of an integrated global education system, where academic links and entitlements could be compared, shared and discussed. Thus computers in education are used in a variety of ways and for a range of purposes.

Countries have formulated different responses to ICT in education as a result of their varied organisation of educational systems, and their cultural, social and economic contexts. This study concentrates on the way in which ICT is utilised by teachers to improve and support learning in all curriculum areas, and therefore when the expression 'ICT' is used without qualification, this is the intended meaning.

In summary this study aims to:

- Explore the innovation pathways that several countries have taken in respect of the use of information and communication technology across the curriculum in schools.
- Identify the factors that facilitate or hinder innovation adoption for ICT in education.
- Predict some of the probable directions of the ICT innovation for similar countries in the next five to ten years.
- Through a comparison process, provide advice for Australia on the field of ICT in education.

As other researchers have found, the specific research questions resulted from a progressive focusing process during the study (Stake, 1995, p. 9). The research questions needed to be broad enough for the study to encompass all the relevant variables within the time and resource constraints applicable. Any framework would need to be sufficiently comprehensive to include a broad range of ICT activities in schools. This indicated a cross-national approach which compared outcomes.

A common approach for the investigation of ICT in education is to separate the equipment, digital content, personnel, policy and legislative elements (Department of Education, Training and Youth Affairs, 2000, pp. 4-5). In this study the approach chosen was a cross-national study where legislation was already in place and where the sources of data would range from expert decision-makers to students in classrooms. This meant that the legislative element would be reflected in discussion about policy which was particular to each country. Also, the equipment and digital content areas were aspects of classroom practice which could be studied together under the wider topic of implementation and practice. Therefore the elements selected were those of policy, implementation and practice, professional development and models of developmental stages. These elements were framed as specific research questions to ensure they were precise enough to be answered, yet sufficiently general to comprehensively cover the field (see Figure 1).

Figure 1: The Research Questions

RQ1a: What has been the general nature of policies in the USA, England and Estonia for ICT in school education?

RQ1b: What were the development and implementation processes of these policies?

RQ2: How have government inputs such as ICT frameworks, targeted funding and accreditation requirements influenced the use of computers in schools?

RQ3: What teacher professional development policies and procedures were evident in the countries studied?

RQ4: In the light of the preceding research questions, is it possible to describe the use of ICT in schools within a particular framework which indicates future directions?

The first of these questions was concerned with ICT as an example of innovation in school education. ICT can be seen as a ‘driver’ (Bijker & Law, 1992) or ‘catalyst’ (Venezky & Davis, 2002, p. 11) in the sense that the technology itself determines the way in which it is used. This view was expressed in the form: “technologies have

trajectories”. An alternative view is that ICT is an ‘enabling tool’ or ‘lever’ (Venezky & Davis, 2002, p. 13) and is therefore socially bound. This view suggests “the impacts of ICT are socially shaped” (Kling, 2000, p. 9) and IT was elevated in general terms as “an enabler of development” for emerging economies (Digital Opportunity Initiative, 2001).

This aspect of ICT in education was examined through research into the policies of the different countries in the study. This was done by examining aspects of policy such as the processes and consultations contributing to such outcomes as policy formation; the nature of any standards frameworks for teachers and students; the funding implications for infrastructure, content and training. Each of these aspects was investigated for linkage to the proposed three-phase model. The results show where each organisation using the policy situated itself in respect of the model, and whether it saw itself moving between the phases. The first research question was therefore split into two parts in order to separate the actual policies from the processes by which they were formed.

The second research question investigated implementation and practice. Policy expresses intent, but it is only one of the factors affecting classroom practice. Following an examination of policy (or intent), it seemed logical to investigate implementation and practice. This aspect of the study looked at the degree to which the intent of policy-makers was translated into practical activity in the field. It also disclosed some activities which had arisen ‘*de novo*’ without a policy initiative. It has been argued that “the thicker the plan the less it affects classroom practice” (Davies, 2001). Therefore this second research question also examined the relationship between government inputs (in the form of ICT frameworks, targeted funding and accreditation requirements) and what was observed happening in schools. This allowed evaluation of the inter-relationship between governmental structures and implementation.

The third research question focused on teacher professional development. The school classroom is led by the teacher, and the role of this person is critical to the adoption of any innovation in the field of education. The way in which teachers have been trained

is very likely to be crucial in determining not only the way in which ICT policy has been implemented, but also the nature of its use in the classroom context. This has been recognised as an important issue in Australia (Downes *et al.*, 2002).

The fourth research question aimed to find what models of development were available. Knowledge of such models, combined with grounded theory derived from the literature and data gathered from the field could then be used to propose new models.

These four research questions were used to organise the study.

1.6 Significance of the study

The research reported in this thesis is important for the following reasons:

First, the study took an international perspective which went beyond reporting each national scene. The policies within each country have received attention locally, but there have been few comparative policy studies. Some international studies have been based upon generic surveys and these have had difficulty comparing data obtained using non-specific frameworks (Collis, 1993; Knezek, Miyashita & Sakamoto, 1994; Plomp, Anderson & Kontogiannopoulou-Polyidorides (Eds.), 1996; Mullis *et al.*, 1997; Eurydice, 2001; OECD, 2001). This study gathered data directly from schools using ICT, giving it a firm foundation.

Second, the study adds to the literature on the diffusion of technological innovations where the consequence of the innovation in school-based education is the prime focus. Little material was initially found relating to this area, and therefore the study makes a valuable contribution. Since a critical element in the thinking of teachers about using computers for education appeared to be the consequences for the children in their charge, this seemed a very important avenue to pursue.

Third, new knowledge was generated about the consequences of common ICT trends in school education. These consequences involve some radical changes to the pattern

of education, and by comparing different countries it was possible to gather evidence about them, thus predicting with some certainty future pathways.

Fourth, the study examined the trend for bigger proportions of education budgets to be expended on the acquisition of information and communication technology (ICT) equipment and services. Understanding and accounting for these expenditures is important for treasuries and school leaders.

Fifth, ICT was shown in some cases to promote higher standards at earlier educational stages, and these had implications for pathways and articulation. School curricula were also being changed in various ways by the potential of ICT. For example, the availability of satellite photographs and weather maps in real time offered unprecedented opportunities for teachers to link the sky patterns visible from the classroom to the view from orbit and the rain coming from beyond the horizon. In Art and Graphic Design the new technology offered students with relatively poor motor skills and co-ordination the chance to produce highly accurate work and to revise this as it progressed.

Sixth, the study is important for decision-makers concerned with the economic justification for students to study ICT. In a context of global competition ICT is seen as an essential ingredient for efficiency and sustainability for national economies. While business uses ICT to become more productive, it is important that school leavers have both generic skills to operate this kind of equipment, and the ability to adapt to future developments. A smaller proportion of students require advanced skills in the fields of ICT, to be able to innovate and develop new systems for commercial purposes. This includes e-commerce, or electronic commerce, where trading transactions are mediated and executed electronically. Pressure from business was present in many curriculum developments associated with the use of ICT in schools, and needed to be appreciated in the context of the other political and educational issues surrounding them.

Finally, this analysis can assist future policy in Australia, particularly with regard to the integration of ICT into the curriculum. During the progress of the study, some

projects were initiated at the federal level in Australia that gave impetus to the research, and further substantiated its significance. These included a project to determine the generic ICT skills needed by teachers through an ICT competency framework (UWS, ACSA, ACCE & TEFA, 2002).

1.7 Chapter summary

This chapter described the reasons for undertaking the research, and its overall importance to the field of education. The theme of ICT adoption in school education was drawn from the field of innovation diffusion and its potential for radical transformation was examined in the context of globalisation. Since the study was to consider matters from a range of countries and language backgrounds, some important matters of terminology were clarified. The main aims of the study were explained and the research questions to investigate them identified.

1.8 Thesis overview

This thesis has five chapters in which the context for the research, the rationale for its undertaking, the methodology used, the findings are presented and the data are analysed and discussed. Chapter 2 reviews the literature and examines many of the current policy documents and theoretical analyses for details of the processes that may be at work in the deployment of computers into school classrooms. Gaps in the literature are identified and the contribution to be made by this study is outlined. Chapter 3 describes details of the approach taken, the implementation strategy for the study, and the evolution of the theoretical framework as it proceeded. Chapter 4 presents the data gathered from the three types of sources selected: from experts in the field, case studies derived from direct observations of practice in schools, and from the policy documentation available in each country. Chapter 5 shows how the data were used to answer the research questions in the context of the literature. It also develops a proposed model and demonstrates its application in the context of Australia, and gives recommendations for applying the findings and for further research.

At best, this thesis represents a snapshot in time. The whole area of ICT in education is moving so quickly that not all of this rapid change can be included.

Chapter 2 Review of the Literature

2.1 Introduction

In the history of education, the 1980s will stand out as the decade during which many countries throughout the world introduced computers in education on a large scale, the first stage of a technological innovation which is unprecedented in its scope. (Plomp et al. 1996, p. 1).

Tjeerd Plomp's introduction to one of the largest cross-national reviews of ICT in education carries an historical viewpoint as well as a judgment. The historical viewpoint identifies the 1980s as the decade in which mainframe computers were supplanted by personal computers on business desks and in homes, also making them immediately accessible to schools and classrooms. It remains to be seen if his judgement was accurate about this being the first stage of a highly significant technological innovation in education.

The focus of this literature review is to examine the background of ICT in schools, and to see what models of stages of development have been developed and used. The review uses the research questions as a framework, looking at policy, implementation and practice and teacher professional development before examining existing models that have been used to structure thinking in the field. The chapter highlights general theories of innovation diffusion, of which the development of ICT in school education is a particular instance. It also analyses the rate of change of the technology behind ICT, because this is an important feature of the field. Findings from previous international studies help to establish the current context of the study, and meta-studies focus on the debate about effectiveness and efficiency of ICT in educational contexts. The final section includes some other relevant factors influencing the use of ICT in schools.

2.2 National ICT policies in the field of education (RQ1)

Schools in many countries are now equipped with computers, networking and Internet connections. It is important to establish what are the expected purposes and the

complex influences behind this growth of ICT in school education. It will be demonstrated that there is considerable coherence between agreed policy rationales and technological drivers for change in the field which have combined to promote this growth. However, it will also be shown that international studies demonstrate a lack of success in achieving widespread good use of ICT in school classrooms.

Despite questions about their nature, national policies for ICT in schools are now widespread amongst developed and developing countries (Nleya, 1998; Kearns, 2002). These overarching policies are reflected in policies developed at other administrative levels, such as state, municipal school board, school and even classroom level, where an individual teacher may have personal rules for the equitable use of a relatively expensive piece of equipment (Kogan, 1978, p.123). ICT appeared to become a significant issue for national policy when international digital communications were promoted by USA vice president Al Gore using the phrase “information superhighway” (Gore, 1994a; Holmes, Savage & Tangney, 2000, sect. 3.3.3). The extensive emergence of policies in this field has subsequently been independent of governmental structure or political persuasion, despite the expectation that these variables affect policy (Dahl & Tufte, 1973, p. 37; Pownall, 1999; Dimitrov & Goetz, 2000, p. 2). The question to ask therefore is what has caused this prevalence of such policies: does it have a social or a technological reason, or both?

The social explanation can be examined from the perspective of interactions between elements of executive power (Dogan, 1975; Page & Wright, 1999; Schmidt, 2001) such as the politicians, professionals and bureaucrats (Lawton, 1986, p. 35). Each of these three groups applied their own schema of values to the situation under consideration, and consequently came to different policy recommendations. The political view of policy-making examines forms of governance and patterns of influence, as these maintain or change social structure. An ideological view considers ways of discussing policy and looks at education as a vehicle for the transmission of culture between generations. The third, economic, view looks at the funding of education and compares this to its contribution to productivity and profit. The synthesis of these views implies that education policy is generated by the interaction of lobbyists (Milio, 1988, p. 109) and others such as politicians, professionals and

bureaucrats who use political, ideological and economic lenses. Understanding the role of political organization and structure is seen as a vital factor in establishing the future of technology in social evolution (RAND, 2002).

This categorisation of power elements in policy development is congruent with other writers about the area of ICT in education (Fabos & Young, 1999, p. 218; OECD, 2001b; Capper, 2003, p.63). Hawkrige (1989) defined three rationales for policy visions which might impact upon the adoption of computers in education as:

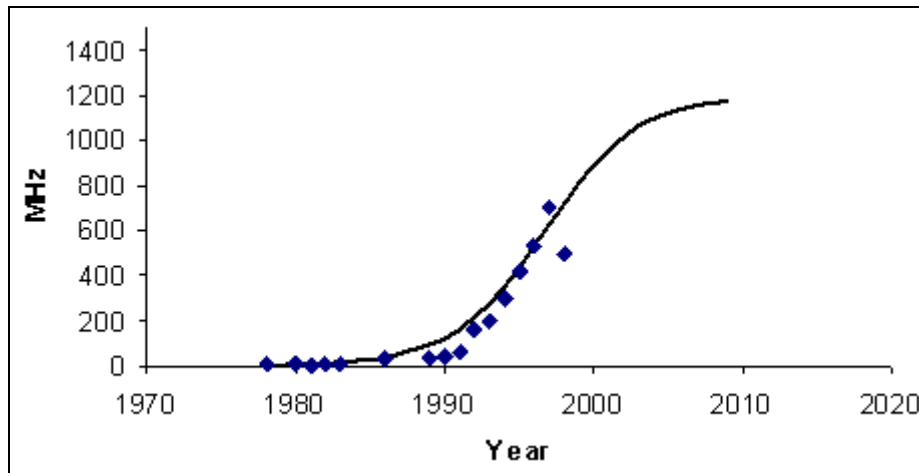
- ***vocational rationale***, necessary for a society to satisfy its requirement to have skilled technological workers, relating learning to future jobs and careers;
- ***social rationale*** reflecting the belief that all students should know about and be familiar with computers as a preparation for active roles in society, and especially to become well-informed citizens;
- ***pedagogical rationale*** which realises the role of computers to improve and enhance teaching and learning.

The vocational rationale is frequently associated with broader policy considerations generally implied by the phrase ‘knowledge economy’ (Commission of the European Communities, 2002; National Office for the Information Economy, 2002). This reflects the way in which ICT-related business has become a significant proportion of national accounts, and is growing so quickly (OECD, 2002, p.3). Translated into education policy, this has meant a concentration on directing resources into student:computer ratios, school Internet connections and technical support (Byrom, 1997, 1998; Birch, 1999). It is therefore appropriate to relabel the ‘vocational rationale’ of Hawkrige, making the three distinct rationales for ICT in school education the economic, social and pedagogic.

The policy drivers for ICT in school education have been reinforced by technological drivers. A common understanding of the nature of policy development is its cyclic nature (Jenkins, 1978, p. 17; Bridgeman & Davis, 1998, p. 24). However, the rate of policy revision and new policy development can be high when environmental considerations raise new and important issues on a frequent basis. This is certainly the case with ICT, where both the underlying technology is developing at a significant

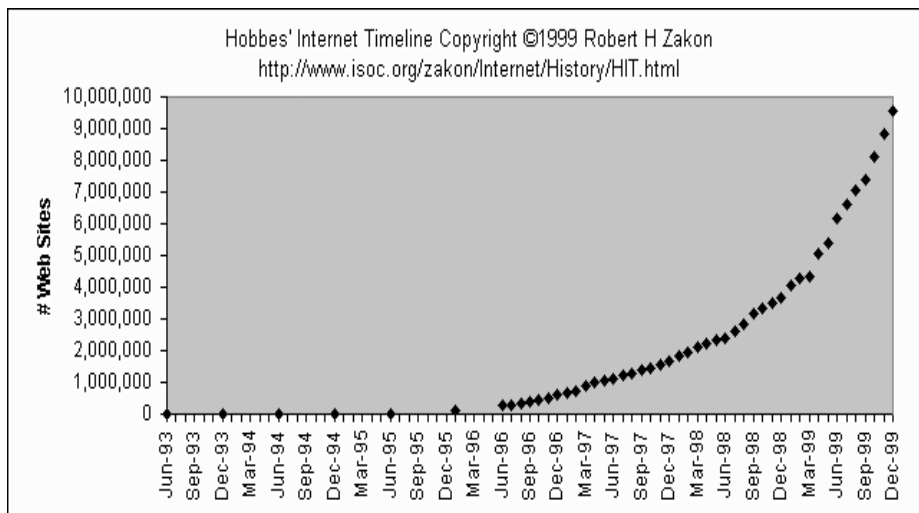
rate, as is its deployment and inter-connection. These aspects are illustrated by the exponential rise of processor clock speeds and world-wide-web connections in Figure 2 and Figure 3.

Figure 2: Maximum announced microprocessor clock speed for each year (Fisher Pry trends line)



(Palmer & Williams, 1999)

Figure 3: Hobbes' Internet Timeline - the growth of hosts and the world-wide-web



(Zakon, 1999)

Although processor speeds in the Palmer and Williams analysis are predicted to peak in 2008-2010, new substrates such as gallium arsenide or diamond (GaAsNet, 2000; Diamond Systems and Sources, 2000) and copper chip tracks (IBM, 1999) make it reasonable to expect ICT will continue to develop in accordance with 'Moore's Law', with capacity doubling every 12-18 months (Moore, 1997; Bitter & Pierson, 2002,

p. 1). An example of an issue generated by expanding hard-disk drive capacities has been the production of 'Replay-TV' devices which take the advertising out of commercial television, thus undermining the economic basis for all commercial television stations (Carrick, 2002). This evidence of a high rate of development contributes significantly towards the suggestion that technology is a significant driver of ICT in schools, alongside any policy drivers. International studies of ICT in education have provided more information about the way in which these parallel political and technological forces have acted.

Six international studies were selected on the basis of their sample size, the wide range of sampled countries and their recency for this part of the review. They are summarised in Table 1.

Table 1: Details of selected international studies into ICT in education

Reference	Sample range	Date of data	Summary
Plomp, Anderson & Kontogiannopoulou-Polydorides (Eds.), 1996 <i>IEA CompEd study</i>	19 countries, 69,000 students	1989 and 1992	Most countries were concentrating efforts on overcoming barriers to integration of ICT in classroom practice. Top-down diffusion was only effective when mandatory
Collis, 1993 <i>ITEC study</i>	16 countries 680 students	1988- 1992	Students using computers displayed higher-order cognitive functions.
Knezek, Miyashita, & Sakamoto, 1994 <i>YCCI study</i>	3 countries 8-21 schools	1992-3	Young children are positive about computers.
Mullis <i>et al.</i> , 1997 <i>IEA - TIMSS</i>	45 countries	1994-5	Student home access to computers varied from 20% to 80% across Europe.
Eurydice, 2001 <i>Basic indicators on the incorporation of ICT into European Educational Systems.</i>	15 countries	2000/01	Education policies are increasingly geared to the use of ICT.
OECD, 2001 <i>Schooling for tomorrow</i>	16 countries	1998-9	National policy approaches identify digital literacy as an important and sophisticated set of competencies.

What these international studies reveal is a range of problems in the implementation of policies for ICT in schools which are gradually being overcome. The barriers to adoption were identified by the CompEd and Schooling for Tomorrow studies as the lack of, or incorrectly placed equipment and software, teacher attitudes and the continuing requirement for high stakes entrance examinations to be completed in handwriting (Plomp, Anderson & Kontogiannopoulou-Polydorides, 1996, pp.11 & 17; OECD, 2001, p.13; Eurydice, 2001, p. 19). The Schooling for Tomorrow project was led by an international working group which conducted a government-level country questionnaire and consulted a network of students to write their report. The authoritative and diverse sources of data were strengths of the project, but the methodology was not evaluated by the authors for a measure of internal consistency to be used in comparison with other studies. The older CompEd study used a far larger dataset with a wider geographical distribution of countries, collecting data from randomly selected students with modal ages of 10 and 13 and those in the penultimate year of schooling. The project also surveyed the principal, computer coordinator and the students' teachers. CompEd and the IEA – TIMSS study both reported that most classrooms had computers, but the use of ICT was generally low with the latter study showing that computers were only frequently used in 10 percent of classrooms of the USA (Mullis *et al.*, 1997, pp. 6 & 162). The IEA-TIMSS study was also based upon a survey, focused on science and mathematics education, with extensive data checking and high internal consistency (Mullis *et al.*, 1997, p. A25).

Despite these difficulties and indicators that ICT in schools was not ubiquitous or well used, there was agreement among the studies that the thrust of policy was at the level of integration within the classroom (Kearns, 2002, p. ii). This was being achieved through policies designed to achieve critical levels of equipment and teacher training (Eurydice, 2001, pp. vii & 17; OECD, 2001, pp.16 & 93). Progress towards this goal was being achieved through a combination of 'top-down' and 'bottom-up' innovation diffusion processes (Plomp *et al.*, 1996, p. 23). The 'top-down' approach expressed in the form of directives in public policy documents appeared only to work when made mandatory. 'Bottom-up' approaches were found to be a necessary complement in Bulgaria and the Netherlands. Home access as a 'bottom-up' strategy was investigated

by the IEA-TIMSS study which found that more than 59 percent of Year 8 students in Australia, USA and England had access to computers outside school (Mullis *et al.*, 1997, p.163) and the CompEd study found boys were more likely than girls in most countries to use this facility (Anderson and Lundmark, 1996). The importance of extending learning at home through the use of ICT was strongly supported in the Schooling for Tomorrow project (OECD, 2001, p.97-99).

The YCCI study used an attitudinal study in a sample of North American, Mexican and Japanese primary schools (Knezek *et al.*, 1994). The survey instrument's internal consistency reliability estimates can be considered acceptable for the English-language and Japanese-language versions with the sub-scales ranging from 0.6 to 0.85 (DeVellis, 1991, p.85). It found that young children were positive about computers (Knezek *et al.*, 1994, p. 7); a finding echoed by the ITEC study which used interviews of principals, observation checklists and videotaping of classrooms using ICT in exemplary ways with students aged 9-10 (Collis, 1993). The ITEC videotapes were analysed by the international project team which found students used higher order cognitive behaviours and were co-operative, motivated and self-confident when using computers in supportive environments. Given the greater range of countries in this study, its results can be supported as being more generalisable than the cross-cultural YCCI study.

2.2.1 Issues from the literature about policy for ICT in school education

It can be seen from the international studies that the current policy thrust for ICT in school education is focused on integration, with positive student attitudes and motivation being the main observable outcomes. Additional studies continue, such as the IEA SITES (M1 & M2) extension of the CompEd work, which has highlighted increasing autonomy of student learning as an outcome of ICT use (International Association for the Evaluation of Educational Achievement, 1999, Fig. 2).

2.3 Implementation and practice (RQ2)

The previous section identified evidence in the literature that ICT is not being extensively or well used in school classrooms. These difficulties in implementation are now referred to the literature in two distinct ways. The first will be through a critique of language used to describe important ideas in the area and examination of the rationales for relevant policies.. This will be followed by a second approach which looks at ICT innovation in schools as a branch of the extensive literature about innovation diffusion.

Descriptive terms concerning ICT use warrant further investigation to clarify what various proponents mean by them. The key words encountered in the literature of this field are ‘integration’ and ‘effectiveness’, often confounded in studies which set out to determine the value of ICT in learning (Woodhurst, 2002). The term ‘integration’ relates to the way in which ICT is incorporated into student learning, and this can be treated separately from its consequences. The literature of the ‘effectiveness’ of ICT integration can therefore be examined as a distinct area. For the purposes of this review, the following definitions were adopted:

ICT integration is the degree to which ICT vanishes into the background of the classroom learning activity.

ICT effectiveness is the degree to which ICT improves or broadens learning outcomes and/or the rate of their achievement by students.

Therefore ICT integration can be seen as an important factor that may lead to ICT effectiveness. The economic, social and pedagogic policy rationales (Hawkrigde, 1989) will be examined against this understanding of ICT effectiveness.

2.3.1 The pedagogical rationale

The pedagogical rationale is founded upon the assumption that ICT can improve student learning. Therefore it is appropriate to begin discussion of the pedagogical rationale by examining instrumentation for measuring ICT integration as the first step for any study purporting to evaluate ICT effectiveness. Several methods for evaluating ICT integration have been proposed (Bingham, 2000; see Table 17 in

Appendix 6.7). These measures share a number of factors with general measures of school effectiveness, such as instructional leadership by the principal, an emphasis on basic skill areas (*i.e.*, reading and mathematics), high expectations for pupils by teachers, enhanced time on task by pupils, an orderly school environment and frequent assessment of pupil progress (Adams & Ginsburg, 1997, p. 3). Of these factors, the ones which matter most and which are alterable were found to be orderly school climate, high teacher expectations for student performance and strong principal leadership (Stringfield & Herman, 1995). There was little difference between these measures of ICT integration and general school effectiveness, with only two specifically ICT-related items, technology capacity and system capacity on the ‘seven dimensions for gauging progress of technology in the schools’ measure from the Milken Family Foundation (Lemke and Coughlin, 1998). Bender (2000) investigated the top 5 schools in Iowa using a set of 11 open-ended questions for teachers (Cronbach alpha of only 0.47) and a 21-item classroom observation schedule which had a Cronbach alpha of 0.88 for internal reliability. Together these two methods assessed teachers’ philosophies and expectations of technology for learning and the degree to which they were implemented in practice, giving it a claim to strength. This and similar instruments, have been used to assess ICT integration and its impact in schools. However, from the preceding discussion, it is clear that measuring integration alone is not enough. We need to look at ICT effectiveness measures, and find out which of these most adequately distinguishes whatever ICT can bring to the learning process.

McDougall (2001) suggests that ICT effectiveness can be assessed “from two rather different, though related, viewpoints”. The first is to examine ICT as an improver of conventional education using experimental and control groups. The other is to consider education with ICT to be so different that additional factors need to be quantified to allow a comparison to be made. The following review of ICT effectiveness uses a similar approach, looking at meta-studies to examine the evidence drawn from the experimental tradition. It then draws upon the descriptive studies before comparing these with critical material in the interests of academic rigour and evaluation.

2.3.1.1 Experimental evidence from meta-studies

A selection of meta-studies of ICT effectiveness in education is shown in Table 2. These meta-studies were chosen for the large number of individual studies represented between them, and for the geographic spread of their samples.

Table 2: Meta-studies of ICT effectiveness in education

Reference	Sample	Findings
Sivin-Kachala & Bialo, 1996 USA	176 studies	ICT has positive effects upon learning. “low achieving students and students with little prior content knowledge are likely to require more structure and instructional guidance than other students” (p.2)
Software and Information Industry Association, 1999 USA	264 studies: 112 professional journal articles plus 44 doctoral dissertations	Teachers with more than 10 hours of training used ICT better.
Sinko & Lehtinen, 1999 Finland	795 studies	ICT has a positive effect upon learning (ranging from 0.28 to 0.5) (see Table 18 in Appendix 6.7)
Parr, 2000 New Zealand	23 meta-studies	Overall, the effectiveness of computer-assisted learning has not been conclusively demonstrated Used effect size of 0.4 as a benchmark.

In most of the above meta-studies, the component studies of ICT effectiveness are compared with one another using the effect size. This has a value of 1.0 if the learning outcomes for a group of students increase by a standard deviation, which equates to 84 percent of an experimental group scoring better than the mean of the control group. The report by Sivin-Kachala and Bialo (1996) found positive gains in educational achievement by students using computers. A larger meta-analysis (Software & Information Industry Association, 1999) was potentially biased by commercial concerns, since over 2,000 sources were reduced to 264. As with all meta-studies, the report faced problems of equating data and findings from a range of sources using sometimes conflicting premises or definitions. These were mostly overcome by eliminating a large number of reports that were weak in methodology (*e.g.*, comparisons of a computer-based instructional treatment to no alternative treatment). The report concluded that educational technology had a significant, positive effect

upon student achievement in all subject areas, from Kindergarten to Year 12. It also had positive effects upon student attitudes to learning. These outcomes were dependent upon various factors such as level of access to technology, software design, student grouping and nature. Teachers with more than 10 hours of training significantly outperformed those with five hours or less. This finding is important to the question of establishing the necessary and sufficient conditions for positive ICT effectiveness.

The Finnish-based study by Sinko and Lehtinen is a rather more substantial work, which was produced by a group of national experts based on over a thousand original research reports. The report deals carefully with potential sources of error, such as the greater likelihood of positive findings to be published, and found that for the early 1990s studies of teaching effectiveness with ICT the effect size, purged of the novelty (Hawthorne) effect, was between 0.30 and 0.40 (Sinko & Lehtinen, 1999, p. 40). More recent studies produced an effect size of this order, with diminishing effectiveness as group size increased (Sinko & Lehtinen, 1999, p. 43). This finding was developed by Parr who compared it with a benchmark for any school innovation of 0.4 (Parr, 2000, section A:1.4). Parr's own investigation of ICT and Independent Learning System effectiveness through meta-analysis found "few studies that yield an effect size that could be considered more than moderate (.3)" (Parr, 2000, section A:2.8). Sinko and Lehtinen agree with Parr on the general size of ICT effectiveness, but disagree about the interpretation. Parr asks us to judge ICT against other (unspecified) educational interventions or innovations. Sinko and Lehtinen ask us to make the judgement between using ICT and doing nothing additional in the classroom. There are good reasons for both approaches. If an additional input (such as ICT) is being contemplated, then to compare its effect against other ways to expend the resources is a valid consideration. ICT appears to be as effective as other innovations, so the pedagogical rationale can be substantiated, but not to a higher degree than other forms of intervention. Sinko and Lehtinen also suggest the social rationale is an important factor in choosing ICT over other innovations, since it can be considered "a tool against alienation" (2000, p. 242).

2.3.1.2 Descriptive studies of ICT in education

This finding that ICT effectiveness is comparable with that of other innovations when measured using experimental methods needs to be compared with the descriptive studies which are now reviewed. A number of descriptive studies were selected for review on the basis of study size (in terms of the absolute number of students involved) and their generalisability. The studies are summarised in Table 3.

Table 3: Descriptive studies of ICT in education

Reference	Type of Project	Findings	Validity, reliability and generalisability
Becta, 2001a & b <i>Schools of the Future</i>	Statistical analyses of reports of ICT use in 2100 schools correlated with pupil achievements	Correlation between ICT use and improved results, even within similar socio-economic bands.	Methodologically flawed since the analysis compared outlier sub-groups.
Harrison, Comber, Fisher, Haw, Lewin, Lunzer, McFarlane, Mavers, Scrimshaw, Somekh, & Watling, 2001 <i>ImpaCT2</i>	60 schools in England - data collected using computer logs, questionnaires and concept mapping	Primary students use ICT three times more at home than at school, and secondary students 4 times more. Interim results suggest ICT is not being used to its full potential to transform learning.	In every case except one the study found evidence of a positive relationship between ICT use and educational attainment.
Mann, Shakeshaft, Becker & Kottkamp, 1999 <i>West Virginia</i>	Statewide, 10 year study	Significant gains in reading, writing and mathematics; ICT more cost-effective than class size reduction; successful with low income and rural students, as well as with girls.	ICT has improved since then.
Pisapia, Coukos & Knutson, 2000	34 schools over three years with five computers and a colour printer in every classroom	It will take 5 years before the full impact of the initiative will be seen. ICT individualises instruction. Some teachers move 'backwards'.	Limited generalisability
Smerdon, Cronen, Lanahan, Anderson, Iannotti, Angeles & Greene, 2000	Analysis of statistical information gathered from three US national surveys.	Only half the teachers who had computers available used them to support student learning.	Useful generalisability in respect of teacher professional development needs.
Wenglinsky, 1998	6,227 fourth graders and 7,146 eighth graders	The impact of ICT depends upon how it is used by teachers. This in turn depends upon teacher PD.	Positive link between ICT use and achievement for 8th grade students.
Woodrow, 1999 <i>Technology Enhanced Secondary Science Instruction (TESSI)</i>	Seven classrooms over seven years	ICT improved secondary science results, and made classroom teaching more individualised.	Limited generalisability

It is in the nature of descriptive studies to uncover a variety of results, and as with all forms of research, they are subject to methodological criticism and have differing degrees of validity. Within this sample of such studies, there are however, agreements on four basic areas: that ICT can improve student learning outcomes (Mann *et al.*, 1999; Woodrow, 1999; Becta, 2001a & b); ICT is not used to its full potential in schools (Pisiapia *et al.*, 2000; Harrison *et al.*, 2001); the impact of ICT depends very much upon teachers (Wnglinsky, 1998; Smerdon *et al.*, 2000); and ICT can individualise instruction (Woodrow, 1999; Pisiapia *et al.*, 2000). The descriptive studies show that ICT effectiveness has considerable potential in the pedagogical rationale when comparing student progress against nationally benchmarked learning outcomes. The Becta reports make a good case for the pedagogical rationale since they found statistical correlation between good ICT uses as observed by Ofsted inspectors and improved results on nationally benchmarked tests of English, Mathematics and Science. A similar correlation was found by the state-wide, decade long Basic Skills/Computer Education (BS/CE) project in West Virginia (Mann, Shakeshaft, Becker & Kottkamp, 1999). Using factor analysis within a regression model, eleven percent of annual basic skills achievement gains (as measured by the Stanford-9 test of mathematics, reading and language arts) of fifth-grade students above normal expected gains were ascribed to the BS/CE project. This finding was statistically significant at more than the .001 level. An economic analysis comparing teacher employment with project costs showed these gains were obtained in a more cost-effective way than reducing class sizes from an average of 21 pupils to 15. This particular study used a representative sample and data validation using multiple sources. It therefore might reasonably be taken as significant. The authors did state caveats as follows:

- BS/CE was based upon instructional learning systems originally designed in 1989 when internet access was just a dream.
- The pedagogy upon which these systems were based does not fit with more modern project or constructivist ways of learning.
- BS/CE was designed for the circumstances and students of West Virginia, and may not therefore be transferable. (Mann *et al.*, 1999, p.3)

This suggests that if the project were to be repeated with more recent technology, the results might be different. Both the Becta and West Virginia studies make a strong case for ICT effectiveness when judged against nationally benchmarked tests. The strength of this case is reduced somewhat when the Becta study considers groups of schools in outlier ICT use categories. However, the methodology demonstrated this correlation irrespective of school management quality, subject or socio-economic background, and this adds significance to the findings. Making a judgement about the West Virginia project is also difficult, since the implication is that newer technology could generate even more positive results, but the mis-match between the BS/CE pedagogy and modern constructivist learning would make one hesitate to transfer it elsewhere. What these studies show is a potential for improvement of educational attainment.

Wenglinsky (1998) examined national standardised mathematics results and found the impact of ICT depends upon teacher professional development. Use of computer-based games positively related to academic achievement, especially in respect of 8th grade students (to the extent of a one third grade level); less so for 4th graders. The Harrison *et al.*, (2001) ImpaCT2 study found evidence in every case except one, of a positive relationship between ICT use and educational attainment. The investigation was conducted by mapping ICT use at home, school and elsewhere against frequency of use to support each subject area through a student survey. These data were correlated with relative achievement on national standardised tests against an initial baseline test. This showed a statistically significant ($p < 0.05$) positive effect for ICT. The results indicated that ICT was not being used to its full potential to transform learning, since relatively few lessons incorporated its use. Together these studies build on the case from Becta and West Virginia by showing learning improvement from ICT being greater for older students, and the importance of including the home environment in such considerations. The ImpaCT2 study confirms the results from the international studies reviewed previously in suggesting the overall amount of ICT use in schools is still quite low, and therefore the full effects have yet to be seen (Harrison *et al.*, 2001).

This untapped potential is confirmed in the remaining descriptive studies. In the words of Seymour Papert, having described the rivalry between the USA and Europe to make ever-faster ships:

In the very same year the first commercial jet plane flew ... it became totally irrelevant which boat could travel faster across the Atlantic. I'd like you to hold that in your minds when thinking about school. Are we trying to perfect an obsolete system or are we trying to make the educational jet plane? (OECD, 2001, p. 112)

This rhetorical question needs to be considered from the point of view of the classroom teacher. His/her main aim for the school day is to survive the class and hope that every student will have learned something of value. Making educational jet planes is not in the job description. Thus in the USA, when Pisapia, Coukos & Knutseon (2000) investigated a computer enrichment project through in-depth analyses of randomly selected classes by classroom observations, focus group interviews, teacher surveys, and software-usage surveys they found that classroom teachers in primary schools changed their perception of computers from being mainly to extend and remediate the core curriculum, to mostly using them to reinforce the core curriculum. The teachers emphasized that they had to expend an almost “overwhelming amount of energy to master the use of computers in their classrooms”, and their personal skill level largely determined the extent to which they were able to improve their instruction. This kind of barrier to innovation diffusion was also identified by Smerdon *et al.* (2000) through an extensive nationwide set of surveys which found that only half the teachers who had computers available used them to support student learning. One-third of teachers reported feeling well prepared or better to use ICT for classroom instruction:

Specifically, teachers who reported spending more than a day (9 hours or more) in professional development [related to ICT] were more likely to report feeling well prepared or very well prepared to use computers or the Internet than those who reported spending a day or less (fewer than 9 hours) in such activities. (Smerdon *et al.*, 2000, pp. 83-84)

This is a helpful finding since it begins to quantify the amount of professional development teachers need to integrate ICT effectively into learning, and make possible an evaluation of its full educational potential.

Woodrow (1999) undertook a seven year, field-based research program of technology integration into secondary science (grades 9-12). The evaluation found better examination results for students in the program, greater participation in the sciences by girls in program schools, and evidence of a change from 50 percent teacher-directed to 80 percent student independent learning. Woodrow deduced that "... a properly conceived plan for using technology can result in the development of pedagogical strategies commensurate with learning needs" (p. 2). She went on to explain how this principle was adopted:

... Technology was not used in TESSI classrooms to simply automate a traditional model of education but to facilitate new ways of instruction and learning, ways to do things better. The program demonstrably produces greater success for more students, addresses issues of gender equity in the sciences, empowers teachers and students, is transferable to other classrooms and achieves long term student benefits. (Woodrow, 1999, p.16)

The story, then, is one where some significant research has been done which measured ICT effectiveness against nationally benchmarked assessments of student learning outcomes, and has found some improvements. However, this empirical evidence also comes with the suggestion that these improvements are not entirely the end of the matter, because the actual amount of classroom use of ICT is quite low, and teachers require significant help in modifying practice to tap its potential.

The situation is illuminated by a range of writers who can collectively be called the critics of ICT in school education. The critics help us to focus on the issues which determine the useful areas of application and how this might be best addressed. Their observations are summarised in Table 4.

Table 4: Critics of ICT in school education

Reference	Summary of argument against ICT in education
Andrews, Burn, Leach, Locke, Low, & Torgerson, 2001 <i>A systematic review</i>	There cannot be much confidence in the results of studies because they fail to explain the mechanism by which ICT may have affected learning.
Armstrong & Casement, 2001 <i>The child and the machine</i>	Suggests there is little real evidence that CAI has educational potential because most analyses underestimate the real cost of ICT which also reduces resources available for other subject areas.
Cordes & Miller (Eds.), 2000 <i>Fool's Gold</i>	Computers have little benefit for children under the age of 6. All users can suffer reduced health through repetitive strains if they overuse computers.
Cuban, 1986 & 2001 <i>Teachers and machines Oversold and underused</i>	Teachers will only accept computers which prove to be reliable and useful. Children are learning more about computers at home than at school.
Peck, Cuban & Kirkpatrick, 2002 <i>Techno-promoter dreams, student realities</i>	ICT has had so little impact because of subject compartmentalism in school organisation and curriculum structures, the lack of project-centred teaching, and technological defects.
Russell, 2002 <i>The no significant difference phenomenon</i>	The numbers of studies showing technology makes no significant difference to educational attainment peaked in 1999.
Shield, 2000 <i>A critical appraisal</i>	ICT has little value in practical subjects which require hands-on training; or for higher-order thinking because current computer simulations do not provide sufficiently rich learning environments.

Andrews *et al.* (2001) repudiated the findings of the meta-studies reviewed previously and found just three percent of the papers examined identified increased motivation and/or confidence in pupils as a result of ICT use with regard to literacy development. They also made the point that “in most of the studies, the conception of literacy is narrow, based on pre-digital notions of reading and writing” (p. 46). Peck, Cuban and Kirkpatrick (2002) found that ICT had little impact because of subject compartmentalism in school organisation and curriculum structures, the lack of project-centred teaching, and technological defects. These comments illustrate the value of critical thinking about the topic, for they begin to show reasons why ICT might not have yet achieved any significant transformation of learning. Other criticisms of ICT have been identified as a product of their time, in the period 1998-2000. Thus Russell (2002) reported a peak in studies in 1999 finding no significant

difference between student cohorts taught traditionally and those taught using various forms of technological system. This theme was taken up by Lloyd (2002) in her critique of Cordes & Miller (2000). Lloyd's counter-criticism to their *Fool's Gold* report argued that it was a product of its time and culture, under the shadow of the "predicted Y2K collapse, in the prelude to the 2000 U.S. Presidential elections, the polar stances of the contemporary media on information and communications technologies and more generally, the doom saying prevalent in any time of transition" (Lloyd, 2002, p. 1).

Additional criticisms of ICT identify the health and safety issues. Against a background of rising obesity amongst children, Cordes & Miller (2000) argued for limitations on the amount of time students remained sedentary, especially those under six years of age. The argument about the link between ill-health and over-use of ICT was also made by Armstrong & Casement (2001, p.143-159). Shield (2000) makes the point that ICT is of limited use when teaching practical skills. Together these criticisms suggest that sensible rules need to be used by classroom teachers when integrating it into their lessons: that as responsible professionals they limit its use to applicable areas of the curriculum within established health and safety guidelines.

2.3.2 The economic rationale

It appears that the research evidence for ICT improving traditional learning outcomes has been supplanted by a need to provide ICT skills and knowledge for assumed economic productivity (Amable, 2002, p.2). The emergence of the 'knowledge-based economy' as a phrase to encompass the importance of ICT in global markets has resulted in national and regional action plans. These plans address issues such as changes to intellectual property law, integration of government activities, transformation of education, digitisation of trade, and health care telematics. Examples of such plans include strategy policies such as *eEurope 2005* (Commission of the European Communities, 2002) and administrative implementations such as the United Kingdom's eMinister with an associated 'Office of the e-Envoy' (OECD, 2002a). The equivalent policy document in Australia is *A Strategic Framework for the Information Economy* (National Office for the Information Economy, 2002) which is supervised by a peak ministerial body called the Online Council. The associated

policy for ICT in schools (Department of Education, Training and Youth Affairs, 2000) is entitled *Learning for the knowledge society: An education and training action plan for the information economy*.

One consequence of these national and regional action plans has been the regular reporting of ICT developments on a comparative basis. For instance, Australia was identified as being second in the world for the percentage of households with a computer, and seventh for home internet access (Di Gregorio & de Montis, 2002). Using the OECD (2002b) information, Australia ranked third in the countries surveyed in terms of the percentage of 15 year olds that used a computer at school at least a few times a week. Therefore it is clear from these measures that Australia is a leading user of ICT.

If Australia is amongst ‘the leaders’ for the extent and use of ICT in education and by young people, why then is there such a huge trade deficit in ICT-related goods and services (Australian Computer Society, 2002)? This question epitomises the pressure from the commercial and government sectors to prioritise work-related ICT skills in schools. One view is that if the problems associated with declining programmer productivity and a fall from global leadership in telecommunications technology are to be solved, then more ICT competent school leavers are important. This view was held so strongly that a project was run by the National Education Performance Monitoring Taskforce in this area. The project report recommended piloting national tests of student ICT skills in Years 5/6 and 9/10 (Cuttance & Stokes, 2000). The objectives of this testing are obscure, since the report refers in one section to the “acquisition of ICT knowledge and skills across the curriculum by all students from the first to the last year of schooling” (Cuttance & Stokes, 2000, section 4), whereas they also identify full integration as occurring “when learning takes place through ICT” [my emphasis]. This distinction is an important one, where the deciding factor is the topic intended to be learned by students. For instance, when students use historical simulation software, are they expected to acquire an understanding of life in the Middle Ages or improve their computer operational skills? The pedagogical rationale argues for the former, whilst the economic rationale would argue for the latter.

The *Real Time* report (Meredyth, Russell, Blackwood, Thomas & Wise, 1999b) made it quite clear that students were using computers more and obtaining their ICT skills at home, not at school. This report puts into question any presumed link between ICT skill monitoring and school ICT training, showing it is unlikely the two will be related. We are left therefore with the alternative suggestion that the benefits of ICT must come when students are learning through ICT, rather than about ICT. The linkage between national competitiveness or economic gains and the use of ICT in schools is therefore one which needs to be examined carefully if it is to be substantiated. Expectations of ICT development (p. 23) also make it questionable whether such skills measured in Year 6 are of any value to a (rare) school leaver at Year 10, and decreasingly so to a Year 12 leaver. The argument here is that the technology will have developed so much in the intervening four to six years as to make such operational skills redundant. It appears that 'knowledge economy' thinking has oriented ICT in school education towards the economic rationale by skewing learning outcomes towards ICT skills for pupils.

2.3.3 Innovation Diffusion

This study focuses on the introduction of ICT into school education. It is therefore related to the general area of innovation diffusion which has an extensive literature (Surry & Farquhar, 1997; Clarke, 2001; Pellicone, 2001, p. 33-53). From rural sociology origins in 1943, the research literature now ranges from the introduction of new linguistic patterns and cultural behaviours, to areas more clearly aligned to the adoption of new technologies in a variety of social situations. There appear to be three important foci for relevant innovation diffusion research: field dependence of the critical factors for diffusion; types of factors and their relative importance; and the particular context of ICT in education.

The literature on critical factors for innovation adoption shows that these are dependent upon the field of application. Parker and Sarvary (1994, Table 8) found 'relative advantage' was the main driver in domestic information technology innovation diffusion, suggesting it will be the nature of the ICT itself which will determine the degree of adoption. Surry (1997) raised the issue of whether a

technology involved in an innovation is more important than the developer or its exponents. He concluded that the adopter has final control and that theories of developer based IT diffusion were deficient in that they overstated the role of technological superiority in the diffusion process. This implies that teachers will have the most significant role in determining the extent of ICT adoption in classrooms. These polarised findings illustrate the debate about some of the fundamental determinants of technological innovation. Since the opposing views come from different fields, there is reason to investigate each new instance of technological innovation separately.

In the specific field of ICT in education, Owen and Liles (1998) classified the factors which facilitated or slowed the adoption of the Internet by teachers such as accessibility of the equipment, training *etc.* The relative costs of equipment were important, as well as teacher attitudes, home Internet connections, transportation distances and difficulty (Tella & Kynäslähti, 1997). Somekh (1998, p. 11) identified suitable transition time, perceived relative advantage, professional development and accessible infrastructure as the critical success factors for ICT diffusion in higher education. The results were congruent with those of Fullan (1991) in school education and can therefore be applied to both fields. The literature thus reveals a variety of important factors, not all of which can be controlled in the adoption process of a technological innovation.

One factor which is perceived as being under systemic control is professional development (Krasnicki, 2003). It appears that an understanding of the content of professional development and its delivery is important to maximising efficacy of its role in the innovation adoption process. Somekh argues this factor is vital to managing the process of change, but has been “startlingly neglected” (1998, p. 20). Fullan agrees with the importance of the factor, but adds “good professional development by itself is not very effective” (1999, p.10). Therefore this controllable factor cannot by itself determine whether a technological innovation will be adopted. The other factors *eg.* perceived relative advantage, accessible quality infrastructure, suitable transition time *etc.*, are also needed for progression through the stages of adoption leading to institutionalisation and permanent integration of an innovation.

The process of innovation institutionalisation can depend upon the different adoption patterns of various types of staff using technology in teaching (Jacobsen, 1998). General recommendations from his study such as such as training, investing in IT infrastructure, and instigating a rewards system could be universal for all groups of computer users, such as the early adopters, the late developers *etc.* The merits of standardisation may not be equally applicable to all these groups.

The literature has therefore identified many of the critical success factors for innovation institutionalisation (Nutley, Davies & Walter, 2002, p. 18). Much of the literature (such as the categories of implementers of Jacobsen) derives from the work of Rogers over the period 1962 to 1995, giving evidence of a well developed field of investigation upon which this study could build.

2.3.4 Issues from the literature about implementation and practice

Some large scale/long term studies of ICT effectiveness using nationally benchmarked outcomes have found it is associated with cost-effective learning improvements. However, ICT effectiveness as measured by meta-analyses is similar to that of other innovations, thus situating the pedagogical rationale for ICT between one-on-one tutoring and no intervention. Criticism has helped to identify the conditions within which the untapped potential of ICT might be reasonable found when usage levels are raised above the current low classroom levels. The basis for the economic rationale has been examined, and the home rather than the school has been identified as the more significant source of ICT skills for students. Previous research has provided little evidence to justify the economic or pedagogical rationales, and some indications of a transformation in schooling. The innovation diffusion literature, particularly that concerning the study topic area, illustrates a range of factors including the perceived relative advantage of ICT and associated professional development.

2.4 Teacher professional development (RQ3)

Teachers have been identified as critical to the adoption of ICT into school education in the previous sections of the review. To clarify their position and reaction to this innovation the review examines the general literature on innovation diffusion to identify the characteristics and skills teachers need if the potential of ICT is to be developed in education to a similar degree to that found in other areas of society. The review examines aspects of teacher culture which make them hesitant to adopt this innovation, and professional development approaches that have been used.

One view is that “technologies have trajectories” (Bijker & Law, 1992). However, there is a considerable literature of innovation diffusion processes that goes beyond this deterministic view. Rogers (1995) defined the process of innovation diffusion in terms of four elements. These four elements occur when an innovation is communicated through certain channels over time amongst the members of a social system. He also described five essential characteristics of innovations:

- Relative advantage (the innovation appears to be better than what was previously available)
- Compatibility (it matches what people already know)
- Complexity (people can understand it)
- Trialability (something people can try in a limited way)
- Observability (potential adopters are able to see the results).

This understanding of innovation diffusion has been widely accepted as a basis for further studies. A key element in Rogers’ model of innovation diffusion is the change agent, who is frequently more technically competent than his/her peers, but can still communicate the essence of the innovation to them effectively (Rogers, 1995, p. 19). Rogers describes the change agent as “a marginal figure with one foot in each of two worlds,” a situation which often leads to role conflicts and problems in communication. This conflict is generally due to their technical competence and their need to relate to potential adopters who have different socio-economic status, beliefs and attitudes. Clayton (1993) extended Rogers’ description of the innovation adoption process by identifying a sixth element of ‘ownership’, exemplified by the apparent emergence of the innovation from a source internal to the organisation. Kazlauskas (1995) concurred, and described the importance of accommodation cycles for

innovation diffusion. Parker and Sarvary (1994) tested the diffusion model using a multi-national survey methodology in relation to a set of home-office consumer electronics innovations. They extended Rogers' theory by identifying alternative pathways for the spread of an innovation within a social system. They concluded that the perceptual product factor of 'relative advantage' was the most significant direct factor influencing diffusion, confirming Rogers' model in regard to this factor. The demographic factors of 'parent ownership' and the psychographic factor of 'venturesomeness' were the next most significant, along with other perceptual product factors such as 'complexity'.

Alternatives to the Rogers' model have been proposed by Valente (1995), Hord, Hall, Loucks-Horsely & Huling (1987) and Rebentisch (1995). Valente (1995) posits a social network background for the majority of innovations, which attributes most of the diffusion process to communication links between individuals. Valente also examines the role of thresholds and develops the idea of a 'critical mass' of the population who must become adopters before the innovation will become more generally adopted. Hord *et al.*, (1987) proposed the Concerns-Based Adoption Model as a diagnostic tool for effective staff development. Rebentisch (1995) proposed a technology-transfer model and found that more complex technologies required relatively more effort to complete their transfers than did simpler technologies. Despite these alternatives, it is clear from the literature that innovation diffusion depends upon the communication of observable relative advantage and ownership.

Setting these findings from the innovation diffusion literature into the domain for ICT integration in school education, it can be seen that teachers need to have exposure to authentic exemplars before they can assess the 'relative advantage' of this new way of working. It is also clear that 'ownership' either of the equipment itself, or control over its disposition, is also another important factor which will influence adoption. Evidence of these findings was confirmed empirically by a group of teachers working in a primary school selected to be a 'lighthouse' for ICT (Ramus, Elliott, Green, Dickinson, Parsons, DiIorio, Huygen, deWacht & Frank, 1998). Over an eighteen month period the staff became "convinced that the provision of notebooks for all teachers was a most effective use of technology" (p. 6). The school quadrupled its

professional development spending; and the teachers used ICT for administration, teaching and material preparation within a collegial context. They indicated areas where this approach was successful with students as including: acceleration through curriculum levels, the intrinsic and instant rewards of success with the software, development of independent skills, co-operative group work and peer tutoring, as well as broadening/enhancement of personal achievements across levels (Ramus *et al.*, 1998, p. 43). The ‘ownership’ factor for innovation diffusion has been used in far larger teacher professional development programs, with laptops for teachers projects operating on a regional basis across the UK (Becta, 2003), Western Australia (Department of Education, Western Australia, 2002) and in Victoria (State of Victoria (Department of Education & Training), 2002).

The application of the innovation diffusion literature to the special case of teacher professional development can also be extended to the area of cultural conflict. Teachers operate in a social and socialising context, where their evaluation of an innovation is in terms of its benefit or deleterious effects. The viewpoint of the evaluator is critical to this judgement, as Rogers acknowledges, describing the definition of “good”, as a value judgement, which depends very much upon cultural perspective (Rogers, 1995, p. 343). It could be argued that beneficial consequences can, in fact, be maximised and undesirable consequences, at least in the short-term, minimised or negated. But Rogers denies this in his generalisation 11-1, saying that “the effects of an innovation cannot be managed to separate the desirable from undesirable consequences”. This distinction is particularly important when considering the social consequences of an innovation such as increased social stratification, and consequent internal inequalities. Agreement of benefit between both internal and external evaluator viewpoints would seem to be a necessary condition for such a judgement.

Therefore the viewpoints of both teaching staff and other elements of the school community need to be considered when assessing the value of information technology in schools. Teachers have internal cultural values, with equity being a strong concern for most teaching staff. The school can be seen as a social instrument to support equal justice for all in society at large. What might therefore be of particular concern to

teachers is the suggestion that a relatively high cost innovation can lead to increased inequality. In such a case the perceptual factor of relative advantage of the innovation will be in opposition to the local culture of equity. Thus the perceived consequences of the innovation are likely to have a significant impact upon its rate of diffusion. Teachers are particularly worried by such social impacts of computers, as was shown in Fluck (1995, p. 69) where they expressed fears about social isolation. This attitude appeared to change in the Tasmanian context by 1998 where teachers:

... noted that "computers are the focus of some friendship groups", and that these groups "cross social boundaries" indicating that membership was socio-economically heterogeneous. When prompted as to their reaction about computers promoting social isolation, these teachers saw computer-using students forming groups (called 'geek gangs' in one school) similar to those formed by students interested in sport, surfing, dressing in fashion, riding horses or doing academic studies. (Fluck, 2001, p. 50)

We now focus inwards on the role of the teacher as a change agent. Moving from general theories of innovation, we need to see where teachers (particularly those in Australia) are in terms of accommodating to ICT, and what professional development is being provided for them. The studies reviewed below show the diverse nature of such professional development, and the relationship between its extent and classroom consequences. The review also brings out the concomitant factors necessary for professional development to be fully effective.

An informal professional development process was used in the *Common Knowledge: Pittsburgh* project, as described by Schofield and Davidson (2000). The project sought to “stimulate teachers in a large urban school system to use the Internet in their work”. It provided the necessary equipment in teachers’ classrooms, and appropriate technical support. While not all teachers who applied and were accepted into this five-year scheme were in agreement, the following findings were reported by the authors as common to a substantial proportion of the group:

- work-related communication with others increased
- interactions within and beyond the school increased
- opportunities for professional development increased
- they learned more about computing and the Internet
- they invested in home computing equipment

- some became school-based network administrators
- they had increased professional pride and enthusiasm.

In the view of their principals, the Internet access project "gets them [teachers] out of the same old rut", and refocused teacher conversation from constant complaints about "kids driving me crazy" to lively discussions of what they were accomplishing (Schofield & Davidson, 2000).

This example of indirect professional development through equipment provision was paralleled by the 'laptops for teachers' scheme in Victoria (Australia) where 67 percent of teachers reported gaining intermediate or advanced IT skills (Department of Education, Employment and Training (Victoria), 2000, p. 32). The Tasmanian Graduate Certificate of Education (Computing for Teaching and Learning) was another example of indirect professional development, structured through a vocationally-based outcomes specification (Department of Education, Tasmania, 2000). Another syllabus that has been considered for a variety of professions is the International Computer Driving Licence (Australian Computer Society, 2002b). Courses following this syllabus have been supplied to teachers in the Australian Capital Territory and by the Catholic Education Office in Parramatta (see http://activated.decs.act.gov.au/prof_learn/online_learn_icdl.htm and <http://www.ceo.parra.catholic.edu.au/pdf/bits/March01.pdf>). The diversity of these professional development approaches indicates the lack of common agreement about the best way to prepare teachers for the general use of ICT, and/or the diversity of expectations.

Other aspects of teacher ICT professional development were considered by Elizabeth Byrom (1997) who reviewed the literature on the integration of technology into education programs. Her review concurred with the ACOT stages of teacher progression and inferred this process generally took three to five years. A RAND study in her review indicated that 30 percent of a school technology budget should be allocated to staff development, and this should take place on-site and 'just in time'. Unless the equipment was available to staff immediately after a workshop, so they could practice and use it for operational reasons within a short time of being trained,

the training effort would be wasted. In a related paper Byrom (1998) identified the factors influencing the effective use of technology in teaching and learning identified through a project working intensively with 12 schools in the south east of the USA. There was a significant positive correlation between the amount and level of equipment and technical assistance provided and subsequent movement along the continuum of technology integration.

The relationship between professional development and technology access/capacity appears to be a significant factor in the development process for ICT in education, as was found by Schofield and Davidson (2000) when teachers involved in their project became more technology-centred. This also suggests that schools that get improved learning results from ICT will have addressed this issue, either directly or indirectly. This is not a surprising result, and basically argues that development will be faster where better resources are available.

An extensive review of teacher professional development with respect to ICT was carried out by Downes, Fluck, Gibbons, Leonard, Matthews, Oliver, Vickers, & Williams (2002). In this review the authors identified four distinct approaches to ICT in education by asking:

‘What educational outcomes do schools and systems hope to achieve by increasing the extent to which ICTs are integrated into classroom practice?’ From the information gathered in response to this question it is evident that, in Australia as well as overseas, educators are promoting ICT use in classrooms for several distinct reasons. These include:

- *Type A: encouraging the acquisition of ICT skills as an end themselves;*
 - *Type B: using ICTs to enhance students’ abilities within the existing curriculum;*
 - *Type C: introducing ICTs as an integral component of broader curricular reforms that are changing not only how learning occurs but what is learned;*
 - *Type D: introducing ICTs as an integral component of the reforms that alter the organisation and structure of schooling itself.*
- (Downes et al., 2002, p. 23)*

It is evident that the nature and type of professional development needs to be aligned with which of these approaches the school is taking to ICT. The review found that school reforms have been increasingly linked to an embedded use of ICT which enables students to undertake authentic multi-disciplinary tasks. Further, these reforms are spreading beyond the school gate as ICT links students to and from external agencies. Therefore it becomes more important to look at ways of conducting teacher professional development at both pre-service and in-service levels that encompass this type of learning experience.

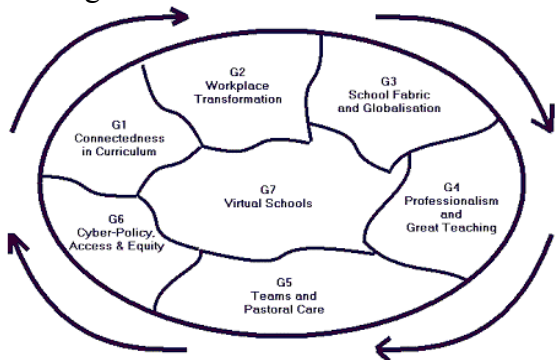
2.4.1 Issues from the literature about professional development

It is clear from the literature that the ICT professional development of teachers is crucial to their role as change agents or adopters of this innovation. Teachers may not feel that they have the background or duty to prepare students for careers or working life that strongly depends upon ICT. Yet there are economic forces at work which suggest this is precisely what they should be doing. Moreover, children are coming to school with increasingly diverse yet increasingly common experiences of ICT at home. How then should teachers react? The social rationale for ICT argues they should ensure all children have the opportunity to develop familiarity with computers. However, teachers have expressed concerns about the social isolation they have observed amongst students who are intensive computer users (Fluck, 1995, pp. 47-48). The third rationale, pedagogy, is a disputed territory, with no clear 2 sigma advantage for ICT (Kraver, 1997), and only an improvement of the 0.3-0.4 effect size is evident in the literature, which is comparable with other innovations. Within these boundaries there are some indicators of the conditions required for ICT to demonstrate a pedagogical improvement. According to Byrom (1997) and Smerdon *et al.* (2000) ICT budgets should allocate a minimum of 30 percent for on-site and 'just in time' training and to provide at least 9 hours training per teacher per year. The training should be aligned to school expectations, depending upon the level of response expected in the Downes *et al.* (2002) list of reason types. Also, ownership is a vital ingredient to change management processes, and this has been taken into account in many professional development programs through laptop schemes for teachers (Clayton, 1993; Ramus *et al.*, 1998).

2.5 Frameworks for the developmental stages of ICT in schools (RQ4)

The literature review proceeds with an examination of recent and significant studies of frameworks for ICT development in schools. There were no documents in ERIC (Educational Resources Information Centre) for the query (stages of development AND ICT AND education) AND (1994< Publication_Date <2003) and therefore the search was widened to include general internet sites, other search engines and printed references. Five works were selected from these sources, and are summarised in Table 5:

Table 5: Selected studies of ICT development stages in schools

Author	Stages of progression	Strengths	Weaknesses
Heppell, 1993	<ol style="list-style-type: none"> 1. Computer as topic 2. Computer supports learning with task specific programs 3. Computers support learning with generic, content free programs 4. Computers support specific needs through component software 5. Pedagogy radically changes to reflect computers' potential 	Has a radical phase change as final step	Includes stages that might be considered redundant
Dwyer, Ringstaff & Sandholtz, 1991; Dwyer, 1994	<p>Apple Classrooms of Tomorrow (ACOT)</p> <ol style="list-style-type: none"> 1. Entry 2. Adoption 3. Adaptation 4. Appropriation 5. Invention 	Transfers well to new situations and has been extensively validated	Only describes the general stages of development for a single teacher in a classroom
Kraver, 1997	<p>Arizona Learning Technology Partnership (ALTP)</p> <p>Wave 1: early adoption</p> <p>Wave 2: ICT integrated into curriculum</p> <p>Wave 3: research-based learning technologies are released and transform education.</p>	Aligns well with ICT-based innovations in other fields.	Assumes a new technology will become available
Caldwell & Spinks, 1998	<p>Schools for the Knowledge Society Track 3 vision gestalt:</p> 	Aligns with emerging national policies to plan for knowledge-based economies	Little evidence for the rhetoric
Valdez, McNabb, Foertsch, Anderson, Hawkes & Raack, 2000	<p>North Central Regional Educational Laboratory (NCREL)</p> <p>Phase I = print automation</p> <p>Phase II = expansion of learning opportunities</p> <p>Phase III = data driven virtual learning.</p>	Emphasises emergence of learner-centred instruction based upon automated monitoring of student progress	Assumes education is school-based and teacher-led

Each of these five models attempts to describe the developmental stages of ICT in education in a different way. The authors have different perspectives which have framed their views. Their audiences, the strengths and the weaknesses of each model, and what they imply for future models are examined below.

Each model is a conceptual one (Webb, 1993) which exists only in the minds of humans rather than having some external manifestation. They are also 'expedient' models (Clement, 1989) which offer explication rather than explanation. Such models can be evaluated by comparing them with the phenomenon under investigation, and are useful for stimulating discussion, making relationships between objects clearer and ultimately becoming the basis for decisions about future actions (Penner, 2001). The focus of each model ranges from the teacher in a school to the system level of school governance.

Heppell wrote at a time when the Internet was beginning to be seen as having potential in the business world, and 'killer-apps' were entering the software marketplace for office automation on a regular basis. His description of the developing role of computers suggested that climbing sales of software which have transformed the world of work will be mirrored in education. He argued that although there had "been neither a strong mechanistic nor a strong causal link between technological and pedagogical change", it was "not an unreasonable contention that this link will need to be tighter rather than looser in the next five to ten years" (Heppell, 1993, p.101). He established Ultralab, the learning technology research laboratory at Anglia Polytechnic University's Chelmsford campus, to trial the application of new technologies in educational settings (Revell, 2002). The Heppell model concentrates on the earlier stages of development, specifying the alternating use of topic specific and generic software. This alternation is not explained within the model, and it is therefore reasonable to be sceptical about its validity. The final stage of the Heppell model suggests pedagogy will change to accommodate the potential of ICT. This is a bold proposition, and requires further investigation to determine its applicability.

The Apple Classrooms of Tomorrow (ACOT) model was presented in support of a project sponsored by a computer manufacturer (Dwyer, Ringstaff & Sandholtz, 1991; Dwyer, 1994). This sponsorship may have affected the conclusions, a caution reinforced by the fact that one of the authors (Dr. David Dwyer) was the Apple director of Education Technology at the time of writing (Apple Computer, 2002, 2002a). The ACOT project was based around the question: “If technology was pervasive throughout education, then what?” Starting in 1985, the Apple Computer company agreed to place a large amount of computer equipment and software in seven classrooms that represented a cross-section of America’s elementary and secondary schools. This included providing a computer for the classroom and home of every teacher and student in each class. The project grew, and with school agreement the classrooms were researched for over a decade. General conclusions about teacher stages of development were drawn from the research, from an ‘Entry’ stage where teachers had doubts, through an integration stage (‘Adaptation’) to a student-centred ‘Invention’ stage.

The ACOT model described ICT development from the point of view of teachers, who might reasonably be expected to be the majority of the audience. Reaching this audience was important to the commercially-sponsored study, for teachers were seen as critical to the acceptance of the technology and hence to sales. In the case of the ACOT model, there is evidence of its appropriation for the formation of teacher ICT accreditation schemes (Office of Technology & Information Services, 2001). The specific levels of the ACOT model make it difficult to apply to school or system level planning, although it could have a use as a component of such plans. Because it relates to teachers, they can use tools based upon the model to diagnose their personal needs for ICT-related professional development, to categorise their current teaching style and to assist in decision-making when choosing new classroom software.

Kraver (1997) developed the ALTP model as part of a case put to bureaucrats and commercial sponsors. His report is therefore framed in language suitable for such an audience. He suggested that radical change of the order of one or two sigmas (standard deviations) in student outcomes should result from the application of ICT in education. He argued that this was not an impossible dream since in other technology

applications “the airline industry doubled speed and range by replacing the piston engine with the jet engine. The food industry has decreased farm labour from 65 percent of the population to two percent using biological and mechanical technology”. One-to-one tutoring had been shown to improve educational outcomes by two sigmas (Bloom, 1984) showing this kind of improvement was not impossible and the capacity of ICT systems to achieve at similar levels was shown through a meta-study review (Kulik & Kulik, 1991). The USA defence department had adopted a similar vision of using digital resources to support individualized, collaborative, authentic and interactive learning in their schools for defence force children anywhere and anytime worldwide, and expected at least a one sigma improvement or a 30 percent teaching time reduction with existing equipment (Fletcher, 2003).

Kraver’s preparatory review of ICT used the STaR categorisation to show that only four percent of schools had ‘target tech’ multimedia computers at a density of one for every 5 students (CEO Forum, 1997). The review refers to a collection of 500 meta-studies indicating ICT improved learning outcomes but did not identify these, casting doubt upon this aspect of the study. The ALTP model showed progression through three ‘waves’, corresponding to increased levels of teacher training, software complexity and ICT funding rising from US\$110 to US\$300 per student per year. In the development of the ALTP model, Kraver makes a good argument for the expected quantum of educational improvement, but fails to enter into the debate about the appropriate metric for validating this. The ALTP model also ties the stages of progression very closely to funding (as was appropriate for the audience) and equipment levels. This is a restricting view, and does not help planners to cope with situations where equipment has been provided but recipients fail to use it. Finally, the ALTP model assumes the emergence of a new kind of research-based learning technology without which the model lacks justification.

Caldwell and Spinks wrote for an audience established by the publication of their first book on self-managing schools at the same time as the Education Reform Act of 1988 in the UK (Caldwell, 1998). Their devolutionary view corresponds strongly with the expectation that multiple solutions can be found locally to similar problems. This view of self-managing schools has been adopted widely in Australia and the United

Kingdom. Their description of self-managing schools was extended into a future vision in *Beyond the self managing school* (Caldwell & Spinks, 1998) which examined future trends and argued that there were three possible tracks along which schools could move. ICT was a vital ingredient to each track, facilitating administrative change on track 1, enhancing communication between teachers as professionals on track 2, and transforming schools as learning places in the knowledge society on track 3. Developments on track 3 were illustrated by reference to lecture theatre design at the Goulburn Ovens Institute where students had alternate seating positions for computing and viewing (Caldwell & Spinks, 1998, p. 177). Among their summary of strategic intentions, they suggested:

Virtual schooling will be a reality at every stage of schooling, but there will still be a place called school, with approaches to virtual schooling including neighbourhood educational houses, especially for the very young. (Caldwell & Spinks, 1998)

The model developed by Caldwell and Spinks has some basis in evidence derived from school architecture, and aligns with policy directions adopted by governments in the ‘knowledge society’ or ‘knowledge economy’ fields. However, they do not present compelling evidence from either source that confirms schools or systems are moving along track 3. The evidence within the development of the model is contradictory, at one point establishing the capacity of ICT to remove traditional barriers of time and distance from the educational process, yet also affirming the centrality of a designated ‘place’ of schooling.

The NCREL model was constructed for “legislators and state board members” and emerged from the development work with which the authors’ organisation was concerned (Valdez *et al.*, 2000). They noted that computer-based technology had been instrumental for increased work productivity and economic success, but debate continued about its value and cost-effectiveness in education. For example, equity concerns had largely eliminated experimental control groups in a three year study of fifty-five New York school districts where increased technology levels accounted for an increase in college entrance examination pass rates of 3.2 percent for mathematics and a one percent increase for English (Mann and Schaffer, 1997). Despite this debate, the NCREL model abstracted elements from successful projects to define stages of progression defined by the curriculum software used by students. The

software stages started with drill and practice materials in Phase I, then moved to group-based learner tools in Phase II before culminating with information systems which integrated student progress tracking with virtual learning in Phase III. Valdez *et al.* (2000) concluded discussion of the NCREL model with a possible Phase IV, ‘Successful Integration and Use of Educational Technology’.

A major difficulty with Phase III of the NCREL model is the implicit assumption that computer systems will generate progress data about learning outcomes for each student. This difficulty is made clearer by examining the work of Means and Olsen to which Valdez *et al.* link the NCREL model. Means and Olsen described four uses of ICT in school education: tutorial, exploratory, tool, and communication (1995, pp. 15-17). Only the tutorial use can be expected to generate data about student progress against learning outcomes. The generic office productivity software increasingly used by students in the other three modes does not report such details. Therefore little information about student achievements will be available for ‘data-driven virtual learning’ in Phase III of the NCREL model. Another difficulty with the NCREL model is the embedding of the industrial approach to learning, with the implicit reliance upon face-to-face direct teaching. The authors appeared to operate in a context where there was institutional support for a vision of the teacher as essential to the learning process, making the profession central to the final phase. This embedded position of the teacher was more in consideration of their audience than from a specific requirement of the technological maturation expected in Phase III.

2.5.1 Issues from the literature about stages of development for ICT in education

The existing frameworks for ICT development stages in schools reveal a number of deficiencies and suggestions for improvement. The first of the difficulties common to several of the models described is that of making ill-founded assumptions. The ALTP model assumes the emergence of a new kind of technology, both the ALTP and NCREL models assume education will mirror ICT impacts in the business world, and the latter also assumes student software will generate progress data. The Heppell model suggests pedagogy will change to accommodate ICT. The implication for any

new model is that it should be thoroughly grounded in the literature and based upon evidence drawn from the field. The only assumptions that can be made are those drawn from existing practice or existing technology.

Another difficulty with the current models is that of internal inconsistencies. The Heppell model inconsistently alternates between a trend to more generic software and the use of topic specific materials. The Caldwell and Spinks model is ambiguous about the capacity of ICT to erode previous thinking about time and place. Any future model should therefore maintain consistency between stages of development by demonstrating the increasing effect of axial principles. To reduce the possibility of inconsistency, there should be a minimum number of stages.

Most of the existing models were crafted for a particular audience. This restricted the generalisability of the models, either for commercial reasons (ACOT) or because of institutional expectations (NCREL). The lesson for a new model is that it should be phrased in very general terms to maintain the widest possible application. This will make it suitable for classroom use or policy consideration, as a basis for professional development or linkage to other levels of national policy.

This generalisability must not cause the model to lose attention to specific requirements for progression between stages. The ALTP model highlighted particular equipment densities and funding levels for each stage, and this was helpful. However, to put such detail in the top level description of a model can limit its audience. Therefore a new model might have a second level of description with this particular detail, having attention to the requirements above about assumptions, consistency and audience.

A final guideline for the construction of a new model through this thesis concerns the difficulties of using conventional tests of educational achievement when students are using ICT in a meaningful way. For example, spelling tests of the traditional model would be inappropriate in the context of children using wordprocessors (such as Microsoft Word XP) in which spell checkers and voice recognition are embedded. The new model should be developed with a view to the possibility that the aims of

teaching may change. By looking at the past and present use of computers (as in the ALTP model), it should be possible to derive a conceptual understanding of how possible futures can link to current practice and previous experience.

The conclusion from this part of the review is that some existing models are limited by ill-founded assumptions, internal inconsistencies, or are restricted to particular sectors of the educational community, industrial conceptions of the schooling process or particular software. Helpful aspects of existing models have related specific levels of training or resourcing to particular stages, and they have been linked to observed practice in schools.

2.6 Other factors influencing the use of ICT in schools

One of the most significant factors about student use of ICT has been the rapid growth of student access to computers and the internet at home. Another has been the aging of the teaching workforce, associated with lower social status and remuneration, leading to a difficulty of recruitment and a search for alternative ways to provide adequate education. This, combined with the desire from both administrators and students to make learning more cost efficient, has met with research evidence that computer-mediated learning can be at least as effective as face to face group instruction.

2.6.1.1 Predictions of home computer access

In Australia children's home access to computers and the Internet has grown rapidly, and is much higher than that for the general population at 74 percent and 48 percent respectively (Australian Bureau of Statistics, 1999b, 1999c, 2000, 2000d). Older children have greater access to computers at home (Meredyth, Russell, Blackwood, Thomas & Wise, 1999b, p.160), with much of their use being for games and educational activities (Australian Bureau of Statistics, 2000c). Similar findings have been reported internationally, with 53 percent to 60 percent of secondary students estimated to use a computer at home in the USA, Germany and the Netherlands (Anderson & Lundmark, 1996, p. 29; Department of Commerce, 2000) while one author suggested ICT be utilised to overcome violence in schools (Fielder, 2000).

Eighty percent of adult Australians undertaking study used the Internet (Pattinson & Di Gregorio, 1998). Therefore it is important to gauge the degree to which national, local and school policies attend to this growing proportion of students that are highly exposed to ICT in their homes.

2.6.1.2 Aging teachers

From 1976 to 1996 the median age of teachers in the USA increased from 33 to 44 years (National Center for Education Statistics, 2000, Table 70). Similar patterns were reported in Estonia, the UK and other countries surveyed. This pattern of an aging teacher population was significant because of the cultural gulf between them and their “Nintendo generation” pupils (Richards, 1997; Abbott-Chapman, 1999, pp. 15-19), and also because of the implications for teacher supply in coming years. Recruitment in the UK has been addressed by a series of ‘golden hellos’ with graduates who elect to go into teacher training receiving £150 per week during the training period, and further large sums when they start teaching in shortage areas such as Foreign Languages, Mathematics, Science or Technology (Charter, 2000). This did not prevent the number of teaching vacancies rising to 4980 by January 2001 (Owen, 2001). Similar difficulties have been reported in Australia (Box, 2000, p. 4) and Estonia where recently retired members of the profession were re-recruited. This re-entry cohort was therefore in a strong position to negotiate for good conditions and wages, and able to resist forces for change in teaching practice.

2.6.1.3 Making learning cost efficient.

Colleges in England for 16-18 year old students were effectively forced into using automation to maximise efficiency to cope with a 25 percent increase in student numbers at a time when the government had begun a program of devolving budgets and management (Kenny, 1994). Examples include the transformation of a ‘low quality traditional lecture based delivery’ engineering course to a “high quality tutorial environment, a flexible, self paced, self guided delivery with computer material available 24 hours a day” (Cartwright, 1994) which achieved the same learning outcomes within a fifty percent reduction in staffing and a twenty percent

reduction in formal student contact time. Leftwich reported similar changes in a politics course (1994).

In the USA on-line accredited college courses were about half the cost to students compared to those that required attendance on-campus (Jurgensen, 1999, p. 16A). Student engagement and motivation were enhanced in a Nebraska study by the inclusion of personal investment content in the course interactions (Lehman, Kaufman, White, Horn & Bruning, 2000). In the school sector, a comparison was made by a UK Minister of Education, Professor Michael Barber:

It has been estimated that the cost of one teacher hour is £,50 in the UK (c. US \$80), rightly rising as we insist on much improved pay for demonstrably good teachers. But the cost of one school ICT hour is about 75 pence (c. US \$1) and falling at about 20 per cent per annum, while computers double their capacity every 18 months. This provides an opportunity not to replace teachers wholesale, but to find new combinations of well-trained teachers, paraprofessionals and technology focused on the learning needs and aspirations of each individual. (Barber, 2000)

This comparison indicates some of the cost pressures which make ICT attractive to educational decision makers. The result has been a proliferation of experimental projects applying ICT in a broad range of educational contexts. Some projects have trialled the use of web-based courses and other multimedia applications with school refusers and at-risk students (EdNA, 2000).

2.7 Chapter summary

The review has identified the ubiquity of national policies for ICT in school education. These policies are often based upon economic, social and/or pedagogical rationales, which require further substantiation. The policies in many countries are becoming subsumed under national policies for ‘the knowledge economy’, and this appears to be shaping their form towards the economic rationale. Despite technological pressures, the extant international studies indicate the thrust of policy is on integrating ICT into current classroom practice, and students use computers much

less in school than outside it. It remains to be seen if student learning autonomy is increased when ICT is used more often.

The literature distinguishes between ICT integration and ICT effectiveness, and several measures are available for each factor. Studies of effectiveness can be classified as experimental or descriptive. Experimental studies typified by meta-studies indicate ICT has so far proven only as effective as other innovations. Descriptive studies have found ICT has potential for improving learning outcomes, providing it is safely applied in appropriate areas, and teachers are adequately trained.

Teacher professional development was examined in the context of innovation diffusion theory. This identified ownership (exemplified through laptops for teachers programs) and the identification of relative advantage as key factors for adoption. However, the literature indicated that professional development needs to be aligned with strategic purposes for ICT. Four such types of school approach have been recognised.

Existing frameworks for the developmental stages of ICT in schools were reviewed in the context of their authors' intentions and specific audience targets. Through an analysis of each framework, it was established that future models would need to be applicable to a wide range of educational audiences, not presume the emergence of new educational technology and not make assumptions about the operational characteristics of software.

Additional factors having some bearing upon the use of ICT in school education were predictions of rapidly increasing home access to computers and the internet, the aging population of teachers and financial imperatives to make learning more cost efficient.

The next chapter will show how the study methodology was developed.

Chapter 3 **Research Design and Methodology**

3.1 Introduction

The main aims of this study (p. 13) included the exploration of national innovation paths in respect of ICT in education overseas and the provision of advice for Australia through a comparison process. It could therefore be classified as being located within the interpretive school of social science (Silverman, 1993), and a mixture of methodologies was appropriate. This chapter outlines the way in which the research approach was developed to ensure the data would be applicable to the Australian situation, and could be used in a predictive way (RQ4). The methods for each research question are introduced and a description is given of the research approach, sample selection and data gathering techniques. The validity, data analysis and limitations of the design are considered.

The iterative construction of the research questions was grounded in data collected from the field. Discussions with national level decision-makers frequently referred to policy documents, and it became clear that these were considered important statements intended to guide classroom practice. To study the way in which policies for ICT in school education were positioned in a country-specific context would have narrowed the research, so a cross-national comparative approach was selected (RQ1). As the study proceeded, the researcher saw a variety of practice in schools, indicating localised responses to national policy. This linkage was therefore examined in further detail (RQ2). In exploring these issues with teachers and relating the importance of change agents from the theory of innovations, the study also focused upon their needs and the way professional development addressed these (RQ3). Bringing these lines of investigation together into a coherent holistic framework was a major consideration of the study (RQ4).

The epistemological basis for the selection of methodologies to answer these four research questions was founded upon an empiricist view of knowledge (Hospers, 1973, p. 183). The paradigm or world-view (Kleinman, 1980) within which the study was conducted was characterised by a reductionist approach that assumes the existence of causality chains (Dufour & Renault, 1998) and the causal principle which

underlies most scientific research (Hospers, 1973, pp. 308-320). The process of transmission from policy statement to classroom implementation does not permit strict adherence to such an experiential view, thus the assumption was made that if an innovation gains increasing levels of adoption, then there is a findable set of reasons why this may be the case, rather than accepting an ontological claim to existence *a priori*. This indicated an approach which identified data of events, people, objects and their interactions as the appropriate material upon which to base the analysis, but did not put boundaries on their immediacy to the innovation diffusion process. The extent to which the findings can be relied upon depends upon the immediacy of causes to effects; for there are many steps and confounding interactions in the journey from national policy statement to teacher activity in the local school classroom. Greater confidence can be expected for closely related steps in the process. The warrant for this choice of method largely depends upon a positivist view within a functionalist paradigm which attempts to interpret the phenomena rather than simply describing them (Burrell & Morgan, 1979, p. 26).

The application of this basis to research questions RQ1a & b and RQ3 ('what' questions) justified a quantitative approach using a positivist paradigm to identify the relationships between the variables. Given the possible number of policies for ICT in school education (at national, regional, school and classroom levels) and their nature, a strict quantitative approach was beyond the resource constraints of the study, so a limitation to national level policy documents was a restriction for these questions. In the case of research questions RQ2 & RQ4 ('how' questions) the use of a qualitative approach was indicated, using a phenomenological/interpretive paradigm to discover the nature of the variables involved. The nature of these two research questions pointed towards an *emic* data collection approach, emphasising the importance of collecting data in the form of verbatim texts from informants to preserve the original meaning of the information (Pelto & Pelto, 1978). The details of the methodologies selected for each research question are dealt with in the following sections.

The research approach generated seven school level case studies, cross-national comparison of policies from three countries and involved 12 formally recorded interviews with experts, school IT coordinators and teachers.

3.1.1 Methodology for the investigation of policy (RQ1)

Policy analysis can be divided into academic policy analysis, where the link between policy determinants and policy content is examined, and applied policy analysis where the link between policy content and policy impact is investigated (Pal, 1992, p. 21). This study was concerned with both the generation of policy and its content, and therefore embraced both these kinds of analysis. Although policy can lead to legislation, this does not necessarily mean the policy is best examined through the resulting Act or other legislative outcome. It is important to identify the appropriate documents for analysis, amongst the issue papers, executive summaries, journal articles, media releases and other instruments used for promulgating or translating policy into practice.

The process of investigating policy generation also needed to include the information available to policy makers, their own capabilities and expectations, and the tools available to them. Policy makers frequently use indicators and surveys as instruments to forecast the likely impact of policy, whether it involves action or not (Dunn, 1994, p. 198). A “policy model is useful and even necessary... [to] ... distinguish essential from non-essential features of a problem situation” (Dunn, 1994, p. 152). The researcher had to select an approach that would identify the correct documents for constant comparison, and tools which would illuminate the underlying theories used by policy makers (Hogwood & Gunn, 1984, p. 18) as they generated the relevant instruments pertaining to ICT in school education. An appropriate approach was therefore to consult experts involved in policy making, and to identify policy documents which would facilitate cross-country comparison.

3.1.2 Methodology for the investigation of practice (RQ2)

The second research question sought information about the linkages between policy and practice based upon information about happenings in schools and the local interpretation of national ICT guidelines. The broad research approach required by RQ2 was one which would support the construction of theory based upon data gathered from the field to address the ‘how’ and ‘why’ rather than the ‘when’ or ‘how

many'. The policy-practice relationships were outside the control of the researcher and therefore an experimental approach was not possible. A longitudinal approach based on a small number of sites in a single context would have provided useful data, but to effectively use the limited time available for the study a multi-national multi-site process was selected. However, a form of case study approach satisfied the requirements and limitations of the study.

Yin (1994, p. xiv) has argued that there are strong reasons for using a case study approach. It is the preferred technique when the researcher has no or little, control over the events (Yin, 1994, p. 1) and when the inquiry is into a contemporary phenomenon within its real-life context, especially when the boundaries between them are not clear (Yin, 1994, p. 13). Such a methodology is appropriate when the issue to be studied is not easily distinguished from its context, and there are more variables of interest than projected data points (Stake, 1995). As defined by Eisenhardt (1989), "case studies can involve either single or multiple cases, and numerous levels of analysis" and the method works well when data are collected from multiple sources of evidence, with data converging through triangulation (Lincoln & Guba, 1985; Jaeger, 1988). Merriam (1988) indicated the importance of the technique for this type of study, suggesting that "a case study approach is often the best methodology for addressing problems in which understanding is sought in order to improve practice." This part of the research design incorporated ethnographic field techniques such as non-participant observation and semi-structured interviews as well as short direct observations.

Therefore the current study used a modified case study approach which gathered data in an exploratory way using constant comparison (Strauss & Corbin, 1998, p. 67) to build theory using several site visits and interviews to understand the perspectives of those involved. An iterative approach used a cyclic process of theory construction (Perry, Riege & Brown, 1998, p. 1955) and return to the field for validation or reconstruction. This modified case study approach combined the observations and interviews with other data such as documents, systemic information about the school, examinations of student work and photographs to explore the variations in ICT policy implementation between selected schools. Initial discussions with national-level

decision-makers were followed by visits to schools, providing an opportunity for comparison of the relationship or gap between policy and practice using a form of grounded theory. The cases were therefore situated in institutions and relied upon evidence based upon multiple sources of data (Gillham, 2000, p.21). Several perspectives were actively sought from at least the ICT coordinator and as many other teachers as could be observed and/or interviewed. The goal of the case studies was to identify critical factors in ICT use which reflected the origin of learning directions and the operational development models underpinning change management in schools (OECD, 1999). Therefore the case studies were written up to facilitate classification of the data into categories (Perry, Riege & Brown, 1998, p. 1956; Strauss & Corbin, 1998, p.114) across the different studies. The case reports are issue-oriented, and therefore it was appropriate for the common approach to reflect all four research questions, which also facilitated triangulation with the data from the other methods.

3.1.3 Methodology for the investigation of professional development (RQ3)

Teacher professional development has many dimensions and takes many forms (Tuviera-Lecaroz, 2001, p. 1). The dimensions include quality, quantity, setting, delivery, responsibility and application. The forms include formal and informal, individual development, *etc.* The critical dimensions of ICT training for differing types of teacher include the emotional aspects and transfer of learned skills to classroom contexts (McKenzie, 1998). Other aspects requiring attention include the way in which planning of professional development is conducted; this can be improved through staff surveys and other assessments (McKenzie, 1998). There is the question of whether pedagogy or technology is the main driver for professional development in the area of ICT for school education. This is particularly important when the delivery is conducted using open or distance learning techniques (UNESCO, 2002). Providing a repertoire of good practice is not in itself a sufficient condition to ensure teachers adopt new pedagogies congruent with the innovation of ICT (Bottino, 2003, p. 5). Therefore the approach taken to collect, evaluate and analyse data about teacher ICT professional development was an eclectic one. Following the techniques used by Moonen and Voogt (1998) data were gathered from structured interviews with teachers in the case study schools and experts involved in related national projects, and from local policy documents in the schools.

3.1.4 Methodology for the investigation of stages of development (RQ4)

Research Question four was designed to analyse the underlying models used in policy making and illuminate forecasts of ICT development in school education. An important part of policy analysis and formulation consists of predicting the effect of possible policy instruments. Included in this process is an evaluation of the consequences of inaction; the effects of a failure to make policy are examined as seriously as possible new policies. The consequences of an innovation are critical to our understanding of policy development. “Policies are built on theories about the world, models of cause and effect” (Bridgman & Davis, 1998, p. 5). Forecasting is a discipline that has its own cast of critics and supporters. It has been argued that all forecasting falls into one of two domains - a view that the future consists of “continuous progressive evolution”, and alternatively, that the future will be determined by “discontinuous change” (Jones, 1980, p. 23). Supporters of developmental futures tend in the main to be optimists and the latter group are inevitably labelled as pessimists. A variety of forecasting techniques are available and include Delphic studies, axial principles, megatrends analysis and modelling. Each of these has some attributes that have made them useful for education policy analysis, and were used to guide the methodology.

The Delphic technique (Hogwood & Gunn, 1984, p.136) was used at the RAND organisation in the 1950s (Gordon & Helmer, 1966). It relies upon the “MacGregor Effect” reported by Loye (1978) which showed that predictions made by a group of people are more likely to be right than predictions made by the same individuals working alone. The technique is particularly useful when the field of interest is so new as to have inadequate historical data for other methods to be applied (Lang, n.d.). The accuracy of the technique for short-range forecasting was established fairly conclusively (Ono & Wedemeyer, 1994), and its validity for long-range forecasting was shown in a 1976 study evaluated much later (Ascher & Overholt, 1983). Difficulties with the Delphi technique centre on the selection of participants, the tendency of individuals to follow group norms (Dalkey, 1972), and coordinators who structure the feedback or frame questions that bias the results (Masini, 1993). A group of 13 is considered optimal (Dalkey, Rourke, Lewis & Snyder, 1972; Debecq, Van de

Ven & Gustafson, 1975; Ziglio, 1996, p. 14). A modified Delphi technique was therefore deemed appropriate for this study, with seven experts selected from the different countries examined. “Be cautiously sceptical of experts ... always use more than one” (Pal, 1992, p. 278). They were all asked the same questions, but not provided amalgamated feedback for a second round of responses. This modified Delphi technique was used as a starting point for the development of a model using grounded theory in the synthesis stage of Research Question four.

The aggregation of terms required by grounded theory for model building was influenced by axial principles and megatrends analysis. These can be categorised as part of the “continuous progressive evolution” domain of forecasting. Bell (1973) used axial principles to describe the development of post-industrial society. Allen (1996) concurred with Bell’s description of the transition driven by production and profit from pre-industrial to industrial society; while knowledge and information are driving the transition to post-industrial society. Given that equity is a matter of significant concern to educational administrators and practising teachers, the application of Bell’s axial principles appears to be a sound and valid approach to employ when considering RQ4. In order to apply this methodology, it was necessary to identify the appropriate axial principles that would determine the adoption of ICT in education.

The megatrends approach is similar to Bell’s axial principles (Naisbitt, 1982; Naisbitt & Aburdene, 1990). The two relevant megatrends are #2 (1982) ‘Forced Technology → High Tech/High Touch’ and #1 (1990) ‘The Booming Global Economy of the 1990s’ which combine to provide the paradox of the highly inter-connected economics of the world and the rise of individualism. Each successive economic revolution (from agrarian to industrial, and industrial to post-industrial) has resulted in a greater degree of independence of the individual. Yet also, at an economic level, each increase in individualism has been built upon trading links that have stretched further afield. An example of this kind of individual empowerment can be found amongst the North Carolina “ruthlessly small” nanocorps, which operate successful one-person businesses world-wide using the Internet (Salmons & Babitsky, 2000). Technology has made large industrial processes more able to accommodate the needs

of single customers into the mechanisms that generate economies of scale (Dawson, 2000, 4.47; Robinson, 2002). The analogous concepts for ICT in school education are the idea of differentiation (catering for the learning needs of the individual) and digital replication (whereby learning materials can be disseminated globally without loss of quality). These concepts had to be factored into the construction of a consolidated framework of ICT development.

The last of the four predictive forecasting techniques to be considered was mathematical modelling. This technique has been used to predict limits to the growth of human societies (Meadows, Meadows, Randers & Behrens, 1972) with a sustainable limit at 20 billion, though most others estimate a peak of about 8.9 billion by 2050 (United Nations, 2000, p. 12). Given this predicted population growth, and the concern for equity and technological determinism expressed in the introduction to this thesis, the question arises as to the linkage between a technology and its social implications. "The shaping of a technology is also the shaping of a society, a set of social and economic relations" (Bijker & Law, 1992, p. 105). An important determinant of the consequences of a technology upon society is the way its introduction is managed through corporate governance, copyright or patent legislation. This was evidenced by the case of the world's most used micro-computer operating system software. Nineteen of the State governments in the USA won a case charging the maker, Microsoft, of monopolistic practices (US District Court of Columbia, 2000). Another determinant of interest to ICT in school education was the penetration of the innovation into student homes, and therefore web-data mining was used to gather data about future access trends and the likelihood of universal home access.

The development of a generic framework for ICT in school education was therefore shaped by the views of the experts through a modified Delphi technique. It took account of axial principles and megatrends illuminated by the case studies and the literature, and reflected the rapidly growing capacities of the underlying ICT.

3.2 Background to the research approach

The literature review provided background on policy making, implementation and practice and professional development in respect of ICT in education. It was important for the research approach to facilitate cross-national insights into each of these areas, because this provided the variety of contexts necessary to give confidence in the conclusions (King, Keohane & Verba, 1994, p. 30). The design process required a series of progressive steps to collect and code data relevant to the research questions to make categories. Using a grounded theory approach, the categories and their properties were then integrated through selective coding (Corbin & Strauss, 1990, p. 14). The initial step took into account the reasons why computers are included in the school curriculum, ranging from a pragmatic and economic rationale to a broader view related to improving the quality of learning in all subject areas. This generated a conceptual understanding of the relationships between the various types of ICT in school education (see Figure 4).

Figure 4: Initial model for understanding ICT in the school curriculum

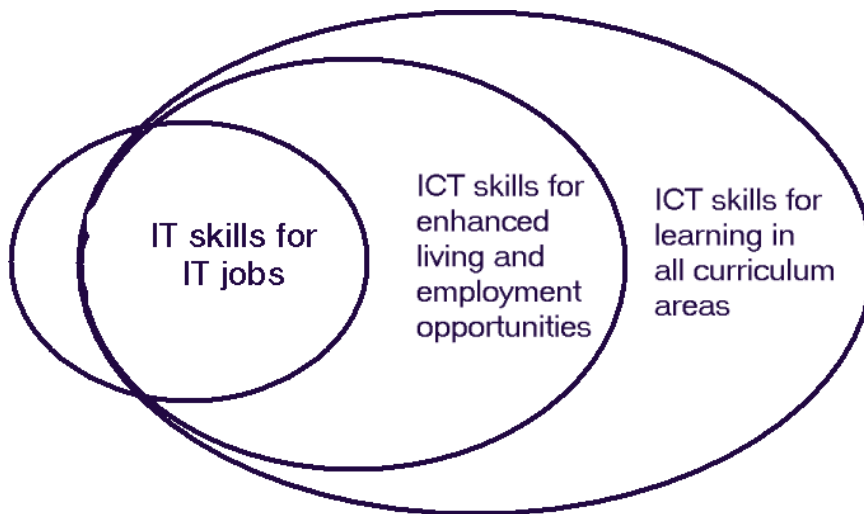
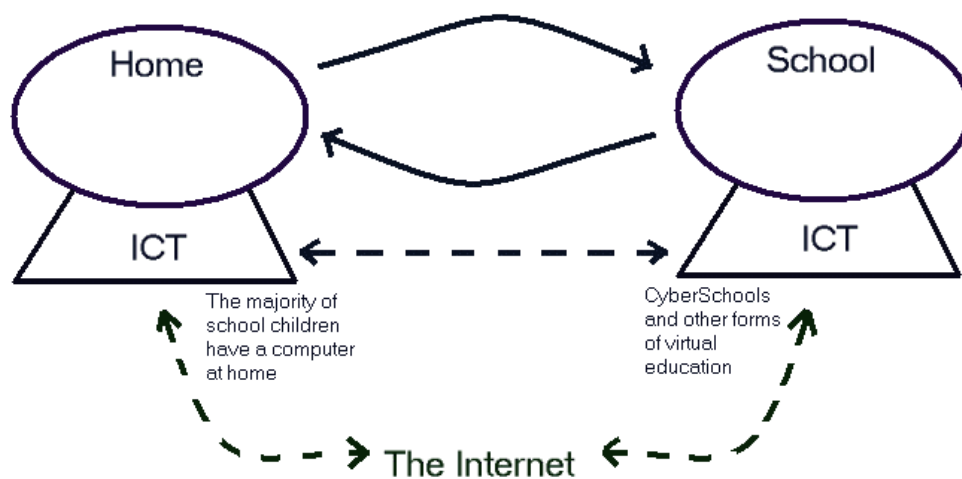


Figure 4 shows an initial relationship between the different kinds of ICT use in learning. It shows that ICT skills for IT jobs derived from the economic rationale are a partial sub-set of those needed for enhanced living and employment opportunities (derived from the social rationale). The skills linked to the pedagogical rationale were seen as a partial super-set of all of these. Questions arising from this initial visualisation were related to the nature of content and process skills of the 'IT skills

for IT jobs’ which were not embraced by the enclosing sets, and the nature of the distinction between economic and social rationales. Also, this visualisation was constructed upon the assumption that all student use of ICT could be categorised together, whereas the literature review had distinguished clearly between the relative opportunities students had to use ICT at home and school (Meredyth *et al.*, 1999; Australian Bureau of Statistics 2000c, 2000d).

As the research progressed it became clear that this school-centric view was insufficient to encompass relevant factors stemming from social and vocational rationales. Economic imperatives for each country emphasised the ‘IT skills for IT jobs’ aspect of the curriculum, yet an increasing number of computers in students’ homes tended to emphasise the use of ICT for learning generally. Therefore, a broader picture of the way in which classroom computer use was situated with respect to external influences was conceived (Figure 5).

Figure 5: Initial understanding of relationships between home and school computer environments



In this figure, solid arrows represent the personal relationships between home and school. This distinguishes them as direct relationships, in contrast to the electronically mediated or “virtual” relationships that are also possible (shown as dashed lines). The figure shows how ICT can be an adjunct or element of school and home life, and also a conduit between these two locales. This communication can be direct or it can be mediated through the Internet, which itself offers additional learning and

communication capacities. These initial integrations of the data were only used as a first step in the development of a new understanding.

3.3 Research approach

A multi-method grounded theory research design that used a comparative case-study approach with semi-structured interviews, content text analysis and case studies would allow the conclusions to be strengthened through triangulation (Webb, Campbell, Schwartz & Sechrest, 1966). A summary of the approach is shown in Table 6.

Table 6: Research approach

Date	Project stage	Data Collection & Analysis
March 1999 – January 2000	Problem definition and literature review	Build document database Content & issue analysis
September 1999	Sample selection (countries, expert panel members & case study schools)	Construction and trial of structured interview formats
October 1999	Approach prospective expert panel members and case study schools	Web-data mining to gather background information on case study schools. Questions sent to proposed interviewees.
November-December 1999	Field studies in USA, England and Estonia (a)	In-depth interviews with expert panel members Data gathering for school case studies: interviews with ICT coordinators, teachers and students, classroom observations, collection of local policy documents, teaching materials and school web-site or systemic accountability data
December 1999 – March 2000	Selection of national level policy documents from web-mining and as guided by expert panel	Transcription of interviews with expert panel members and case study school teachers Participant review Writing case studies Content & issue analysis Writing up of thesis
January 2001- August 2002	Writing of journal article, national conference organisation and work commitments	See Fluck, 2001b; http://www.pa.ash.org.au/acec2002/default.asp
September 2001	Field study (b) in Estonia	Obtain new national level policy documents
September 2002	Field studies in Australia	Data gathering for school case studies (as before) Writing of additional case studies
October 2002-May 2003	Analysis and reporting	Open coding of interviews and policy documents; category formation, property allocation and dimensioning Category grouping and logic diagram construction Writing up of thesis

Tools were required to gather data relevant to each Research Question. Although each question covered a different area, there were many overlaps among them (such as the linkage between policy and professional development which is often subject to policy guidelines). These overlaps were also encountered when data sources were selected and they illuminated more than one research question. First-order (raw) data (Eliasov & Frank, 2000) was collected from decision-makers at the national policy level and additional information was collected from public and private sources to provide contextual data for each participant. These additional sources included web data-mining (Hearst, 1997) and published literature to provide alternative perspectives. Each of these grounded the data in the field, adding to the soundness of the findings.

3.4 University ethics approval

Permission for the project was sought from the University Ethics Committee. The proposal contained full details of the research approach, a description of the project and the framework for the semi-structured interviews. The study was approved, with the condition that an Information Sheet be produced for participants in the study. This was done and is included in Appendix 6.5.

3.5 Sample selection

There were three separate samples: first, of countries for inclusion in the study; second, of individuals for the expert panel and third, of schools for the case studies.

3.5.1 The sample countries

The countries sampled for investigation needed to have significant levels of ICT use in schools, otherwise there would be nothing to include in the case studies. However, to make the study generalisable, they also needed to have as rich and broad a range of cultural values and other factors as possible within the limitations of travel budget, time available and researcher linguistic ability. This sample is therefore a purposeful

sample, chosen for the maximum opportunity to learn about the phenomenon (Merriam, Mott & Lee, 1996, p. 9).

The USA was selected because of its globally dominant position in trade and politics, together with its reputation for advanced uses of computers in education. The link between the researcher's professional association in Australia and ISTE in the USA was also an enabling factor.

England was selected because of the parallels between it and the USA in respect of ICT in schools. The commonality of language between the two countries and the researcher's own made these easily approachable sources of data, especially valid for comparison with Australia. Their similar characteristics in terms of GDP per capita, student:teacher ratios and students/computer made them valid comparators for the Australian situation.

The validity of the study would have been restricted if data were only collected from wealthy highly industrialised countries. Estonia was chosen as a suitable contrast to these other countries. It had a very low GDP per capita and a very small population with national income principally deriving from forestry resources. However, it offered an environment accessible to the researcher, since English was widely understood and it had a reputation for advanced take-up of computers in the post-Soviet era. The existence of the Tiger Leap Foundation as a national organisation to promote ICT in schools gave a point of contact similar to that found in the UK and USA. The number of Internet hosts per head of population was above average for its GDP (Dodge, 1998) putting it on a similar level to the UK in this respect (UNDP, 2000).

3.5.2 The sample of expert panel members

Communication is an essential characteristic for the diffusion of innovative ideas (Valente, 1995; Karsten & Gales, 1996). Strogatz and Watts (1998) argued that ideas spread through personal contact (bottom-up) as much as through media (top-down) in their investigations of small world theory. This theory emerged from a study of communication networks and allows the conclusion to be drawn that human networks have a connectivity somewhere between that of regular and purely random networks

(Monge & Contractor, 2002). An average of 3.65 links was found between the 225,000 socially connected actors around the world (Matthews, 1999; Watts, 1999). The social network of educators involved with ICT can be considered in the same way, especially since they were highly likely to be laterally connected through Internet access in the post-modern networked organisational form that has evolved through modern communications technologies from top-down hierarchies such as bureaucratic and multidivisional forms. Members of the expert panel were therefore approached to form an opportunity sample following identification in the first and at least one other of the following categories (which are also used in the following Table as selection criteria codes):

- 1) The individual was involved through an executive role in educational ICT projects at a national level, and
- 2) Was a senior member of an organisation with a prime responsibility for ICT in school education; or
- 3) Was recommended by at least one other member of the expert panel as having a significant role; or
- 4) Was appointed as the spokesperson by a national organisation which had a prime responsibility for ICT in school education.

The membership of the expert panel is described in Table 7, representing a mix of national decision-makers and people engaged in projects of national significance.

Table 7: The expert panel.

Country	Expert panel member	Position [and selection criteria]	Responsibilities
USA	DM	Vice-president of International Society for Technology Education (ISTE) [1 & 4]	Nominated by ISTE: manager of national project on teacher and student ICT standards
Estonia	EM	Director of nationally funded 'Tiger Leap' computer education project for Ministry of Education [1 & 2]	To provide targeted co-funding for school ICT equipment and direct a program of professional development for teachers
Estonia	TE	National project officer [1 & 3]	Direct externally funded project to develop administration information systems for schools
England	NM	Schools Director of Becta [1 & 2]	Direct research and development into ICT in schools
England	KB	Officer of Teacher Training Agency [1 & 4]	Implementation of national program for teacher professional development in ICT
England	MR	Independent consultant [1 & 3]	Quality assurance of national program for teacher professional development in ICT
England	BM	Professor of Education in University largely using distance delivery of education [1 & 3]	Major supplier of professional development for national program of teacher professional development in ICT

3.5.3 Selection of schools for case studies

In each of the sample countries one primary and one secondary school from the public sector with mixed gender students were selected for the case studies. The schools selected for case studies were chosen because:

- They were accessible from the locations designated by the members of the expert panel for their interviews.
- There was sufficient information available on the world-wide-web about each school to assure the researcher that ICT was being used across the curriculum.
- They were not selected on the basis of exemplary performance in respect of ICT (except in Estonia where selection was guided by the national 'Tiger Leap' team).

The case study schools therefore represented an opportunity quota sample. In one case (a primary school in England) the school selected was not visited because of illness of the responsible teacher on the agreed meeting date.

3.6 Data gathering

Data were gathered from three sources (policy documents, expert panel and school case studies) using two main tools. These were the face-to-face interview and web-data mining. This section describes the protocols used in conjunction with these two tools. Concerns about the unjustified use of multiple methods have been raised:

Two poorly designed and sloppily conducted evaluation strategies will yield no better picture of the findings than one poor study. Mark and Shotland (1987) maintain that multiple methods are only appropriate when they are chosen for a particular purpose, such as investigating a particularly complex program that cannot be adequately assessed with a single method.

(Reeves, 1999)

In this study multiple methods were intentionally chosen to maximise the trustworthiness of the data. The establishment of a framework in Research Question four from which future directions for ICT in schools could be derived was a complex task for which multiple methods were appropriate. Documentation would provide data about existing practice, but future directions would be more easily identified through interviews with the national-level decision-makers to determine the pathway they perceived policy was on. These data were then combined with those from the case studies using selective coding and model building.

Following piloting, the structured interview formats were changed to make the questions to each of the three categories of respondent sufficiently distinct, but with overlaps in respect to policy and home use of ICT. When the questions were sent to interviewees as part of the meeting arrangement process, queries about local interpretation were answered by e-mail. This gave a commonality of approach and helped to make the interview a more productive event. The interview technique enabled narrative inquiry where the contributors to the study built a story of the situation as they saw it from a personal perspective. In this sense, the perspective gained was a privileged one, since most of the participants had highly instrumental

roles in the determination of public policy for computers in schools. The partisan nature of this perspective and possible participant halo effect was moderated by the school case studies and policy document content analyses (Cohen, Manion & Morrison, 2000, p. 157).

Through their responses to the structured interview questions the interviewees told the national history of ICT in education, revealed some of the hopes and fears of the policy framers as they perceived them, and described their expectations for future directions. The researcher had to strike a balance between encouraging trust which would enhance disclosure, and over-emphasising the importance of any particular statement which would bias responses. He was a foreigner and therefore this mitigated against hiding otherwise unpalatable aspects of the decision-making process because the interviewees were not having to justify their actions to the group of people that had been affected. This encouraged interviewees to be as revealing as possible.

3.6.1 Interview procedure

Face-to-face interviews were selected over telephone calls or written surveys because of the small number and preference of participants, their key nature in determining policy in their countries, and the possibility of improved openness in face-to-face interviews (Gillham, 2000, p. 62). The selected individuals were contacted by e-mail to request their permission to participate. When an appointment had been agreed, the individuals were sent by e-mail a short introduction to the study, its main aims and research questions, together with a set of questions to be addressed during the interview (see Appendix 6.4), at least three weeks before the appointment (except in one case where a national expert was recommended for inclusion during the country visit). A request to consider permitting audio tape-recording was included in this exchange of e-mails. Most interviewees found the questions a useful guide to the general area being investigated. In most cases participants asked for a further verbal explanation about the questions as a preliminary to answering.

The interviews were conducted on a private one-on-one basis at their workplace², helping them to be at ease to overcome apprehension and thus increase openness. At the commencement of the interview each respondent was asked if they consented to audio-tape recording of the conversation, and this was done only with approval. While the interviews were conducted using the structured interview schedule, other issues originating from the interviewees were followed using probes (Gillham, 2000, p. 69) such as “please explain that to me” or “how does that link to...?” The importance here was to maintain a balance between consistency and discovery (Strauss & Corbin, 1990, p.182). At the conclusion of the interview, the respondents were given an opportunity to request a transcript for review. Only one such request was made and the transcript was emailed back to the respondent within a month. It resulted in no changes to the transcript. As soon as possible after each interview, the recordings were transcribed, reviewed and edited using Dragon NaturallySpeaking voice recognition software (Zick & Olsen, 2001), which was reasonably fast and accurate.

3.6.2 Gathering information using data-mining from the world wide web

The collection of policy documents and case-study information formed two parallel activities in this research study. Policy documents were gathered from the initiation of the project in 1998, and this collection was added to throughout the study to December 2002. Case study information for each country was gathered from the world wide web prior to visits in November/December 1999, and from the interviewees at that time. In many cases these informants referred the researcher to materials that were accessed through the Internet or by post after returning to home base. Many of the materials were available in electronic form. They were stored locally in conjunction with the reference list for the thesis in web-format to form a database that could be searched by keyword or author.

² Except in one instance where a quiet pub was selected by an expert panel member as convenient for the travel arrangements of both parties. The session was made silent for one minute in recollection of Armistice Day.

3.7 Reliability and validity

The general question of validity of the data requires the researcher to examine other possible explanations for the observed phenomena than the broad aims being investigated. A variety of methods could be used to determine the authenticity of research findings, but a general helpful distinction is drawn between issues of internal and external validity. The issue of validity of the data was considered against the criteria established by Campbell and Stanley (1963) and revised in Campbell (1969). Since the study was not essentially experimental, the history effect was not strictly applicable since there was no pre- and post-test to determine the effect of a treatment. However, in a wider sense there was a need to separate out the behaviours which related to ICT in education and those which were the result of other factors such as new curriculum frameworks, changes of government, *etc.* The threat was addressed by the researcher becoming contextually sensitive, demonstrated by including a short description of each country investigated in the Appendix, and by giving relevant background information for each school case study.

The problem with regression artefacts was considered. This threat occurs when individuals in a study have been selected upon the basis of extreme positions. In some ways it could be argued that all the participants in the case studies were fundamentally in favour of computers, since each had a position of responsibility at some level to manage, introduce or encourage the use of computers in schools. In this sense they were a biased group. However, the study was aimed at tracking and describing the growth of ICT in schools, and to this end it was important to contact people who were involved in the process rather than detractors or those who were uninvolved, since they could probably contribute little knowledge to the study. Many of those interviewed (particularly MR) espoused a highly critical view of some uses of ICT in schools. Such a critical view was in alignment with his quality assurance role for the national training scheme. In each country except the USA more than one expert was interviewed, and this provided an opportunity to verify statements, reducing the threat of bias amongst respondents. The possibility of collusion remained, but the choice of experts from different countries and sometimes competing organisations helped to moderate the risk. The threat to the validity of the study was acknowledged and considered in the analysis stage of the work.

The selection threat was a potential threat to internal validity, since the various countries would be compared in the analysis. However, there were a limited number of people in each country who had carriage of the ICT agenda in schools, and it was from this group that selections were made. The bias occurring from the actual selection was to some extent mitigated by the literature search to ensure interviewee data were related to published material. Experimental mortality was only a threat in Estonia where academics in the University of Tartu who had historically been involved in setting up the national ICT program were unavailable for interview. This was not a significant problem since the actual respondents had largely taken over and were driving the process along new paths that extended planning from previous years.

The selection-maturation interaction effect on the data was of particular interest to the study since differential rates of autonomous change between countries were being mapped and followed. The choice of countries for study was important to address this aspect of validity because they included culturally diverse and developmentally overlapping sources of data.

External validity was also considered in the light of Campbell's (1969) list of potential threats. If the analyses of the policy documentation, interviews with experts and school case studies were to be applied to the Australian situation, it was necessary to examine any potential source of bias that might make the findings inapplicable. The constraint on transferability lay in the differences in governmental structures and the various priorities for schooling within each Australian state. The interaction effects of testing were considered unlikely to be a problem in that the chances of any particular respondent communicating with any other about the research program were considered small. Although it was possible that respondents could interact with national level decision-makers in Australia and that some of this (especially in the case of professorial exchange visits or international conferences) could be influential, was not a threat that could be eliminated. It was however mitigated by the relatively small number of experts interviewed.

The interaction of the selection and experimental treatment was not a consideration as no treatment was given in respect of the school case studies, and this applied to multiple-treatment interference. The general class of 'Hawthorne effects' as a reactive effect was not considered significant, since the whole area of investigation was one of dynamic change and perpetual evaluation which simultaneously made this unavoidable and backgrounded the risk. The experts on the panel were in a good position to make strategic decisions and may have tended to be positive about their own country. However, because of their significant roles, they were also aware of any shortcomings of policy or implementation, and this aspect was probed to provide balance and neutrality to the data. The case-study schools were susceptible to this threat, so it was minimised by approaching the school directly through the principal and organising visits which would disrupt teaching activities minimally.

The threat to validity posed by Campbell's (1969) irrelevant responsiveness of measures was considered seriously since apparent findings emerging from irrelevant components would compromise the findings. The process chosen to reduce the significance of this possible threat was to triangulate the data sources (policy document analysis, interviews with experts and school case studies). Common results between two or more of the sources would be less susceptible to this threat.

The irrelevant responsiveness of measures was a threat to be considered seriously since apparent findings emerging from irrelevant components would invalidate the findings of the study. The process chosen to reduce the significance of this possible unreliability was to 'triangulate' (Campbell & Fiske, 1959; Cohen, Manion & Morrison, 2000, p. 112) the data sources (literature, interviews and observations) and draw conclusions for each case study country where these aligned. This could not be guaranteed to eliminate all such sources of error, but the process could be used to give an estimate of the probable validity of each finding.

Finally, the irrelevant replicability of treatments alerted the researcher to the possibility of findings that were not due to the components of the complex situation under study. For instance, any generalised model of stages of development that might be discovered could be distorted by a sudden change of government to one that

decided to eliminate ICT from primary schools. Alternatively, the study might concentrate on identifying the characteristics of phase transitions between stages of development, when the underlying mechanisms relied upon fewer or more stages. This was not an easy threat to meet except by emphasising the ecological validity of the study (Johnson & Christiansen, 2000, chap. 7). Data collection was enhanced by conducting the research in natural settings, which required attention to the description of explanatory variables as well as the setting (Open University, 1979, p.40).

Since a multi-method methodology was selected, the general question of validity needed to be dealt with in different ways for each type of data source. In the case of policy documentation describing curriculum or training initiatives, these were collected by the researcher from individuals involved in their development.

In the case of materials available from the world-wide-web, these were generally downloaded and stored locally to permit the investigation of meta-tags and other authentication markers. Although this does not of itself guarantee the provenance of a file, a local copy did permit re-visiting of the version that was available on the day of download. Access to these materials is not provided on the CD-ROM version accompanying this thesis because of copyright restrictions. However, the references section states the full uniform resource locator which can be used to locate the website of the source institution.

In the case of personal interviews, the interviewer transcribed these as soon after the event as practicable. Great care was taken to make these as accurate as possible, with the interviewer's own comments being as faithfully transcribed as those of interviewees. A full transcript of each interview has been made available on the CD-ROM version accompanying this thesis, for purposes of verifying the analysis.

3.8 Data analysis

The data were analysed using the principles of grounded theory research according to research question and source. The procedure of data collection was accompanied by the process of descriptive coding to organise situations, personal perspectives and

literature in ways that were meaningful. This process was followed by typological analysis (LeCompte & Preissle, 1993, p. 257) which aggregated similar categories.

Data from the sample countries were selected and investigated at three levels. The first level was that of national policy, undertaken through text analysis and comparison and synthesis of interviews with national-level policy-makers. The second level was that of schools, where once again extant documentation was examined and the ICT coordinator interviewed. The third level was that of the classroom, where the researcher visited teachers working with computers in a range of educational disciplines, to see to what extent national and school policy had penetrated into classroom practice. Data from the school and classroom levels were synthesised into school case studies, structured in a standard form related to the research questions. The school case studies were analysed using the process of constant comparison, which allowed data from several different sources to be integrated.

As data were gathered from a variety of sites, content analysis was used to identify significant categories and commonalities (Gillham, 2000, pp. 71-75). Interviews were analysed using issue analysis through grounded theory (Lincoln & Guba, 1985, p. 205) because of the small number of experts, the time available and the focus on issues. This evolved into a developing framework to assess ICT integration in Australian states, and to make a judgement about development pathways. The use of an evolving framework employed an iterative process of re-examination of emerging categories during data analysis, maximising the opportunity to accept new knowledge (Pandit, 1996).

3.9 Limitations

All research embeds decisions about the balance between available resources and the effectiveness of techniques. It was important therefore to recognise potential sources of bias and error in the conduct of this study. Researcher bias emanating from personal reasons for wanting to conduct the study was a consideration. This was regarded as an acceptable limitation since the motivation component was a necessary condition for the study to be completed. There were further possibilities for error due

to terminological inexactitudes and other human communication problems. Efforts to eliminate these sources of error were considerable. The discussion in a previous chapter attempts to precisely identify the meaning of the vocabulary used in each country, as one way of translating comments into a standard meaning. In addition, when in Estonia, the researcher took every opportunity to match what was said at interview with materials translated into English by an independent person.

While interviews were conducted in a friendly vein, the researcher attempted to remain non-judgemental and to interact with what the interviewee said. This strategy was used to assure respondents their opinions were appreciated and to increase their openness. It cannot be known to what degree their disclosure was influenced by this strategy, or whether significant bias in the nature of their opinions resulted.

A limitation in such a study can be the difficulty of respondents being under pressure to overstate the positive side of their story, and therefore be biased in their responses (Yin, 1994). Conducting these interviews privately in the workplace of the subjects minimised these pressures, since they were not on public display and the researcher made it clear that the intention was to publish findings based upon results gathered from a mixture of settings and countries. The process of exchanging e-mail before the interview helped to establish a degree of trust. This trust was built into rapport by responding equally to positive and negative examples of ICT in the interview. This meant the interviewer was open to alternative interpretations of the development pathway expressed in the proposed model. In addition, much of the data was gathered from multiple sources, such as several experts in each country, case study information from documents and interviewees and so on. The audio-tape recording of interviews enabled a more objective analysis to be conducted after the event. These multiple perspectives facilitated the verification of data (Merriam, 1998).

Another limitation of this study relates to the small number of countries included in the case studies. While a certain diversity of cultural background was incorporated into the design, the majority were English-speaking and Anglo-Saxon. A greater range of validity might be claimed if a greater diversity of cultural backgrounds had been included, such as more African, South American and Russian examples. Data

from such geographically dispersed and culturally different situations could have led to greater generalisability of the study. In mitigation of this limitation, the increasingly competitive environment of globalisation (Peng, 2002, p. 18) was tending to make economies converge, providing a reasonable degree of generalisability to the findings.

3.10 Chapter summary

This chapter has provided a description of the study methodology, and the substantiating rationale for its adoption. Policy documents were selected with the guidance of the expert panel members and their contents analysed comparatively. Practice was investigated through case studies using multiple perspectives, while teacher professional development was studied using a variety of sources, including school-level policy documents. Stages of development were considered through interviews with the expert panel members which were extensively coded to form categories using a grounded theory approach. The emerging theoretical framework was critiqued, as well as the protocol for conducting interviews and gathering other data. The issues of validity and reliability were discussed.

The following chapter describes the findings from the policy document comparisons, what the experts said and the school case studies.

Chapter 4 Results

4.1 Introduction

The results presented in this chapter comprise the findings from the three types of data source: policy documents, expert panel and school case studies. Presenting the data as country-level case studies was rejected since this approach would have delayed the cross-case comparisons so vital in issue analysis. Therefore the data are presented by research question, integrating the data from the different types of source through triangulation (Smith, 1975, pp. 271-276). This technique uses multiple methods to investigate a single phenomenon but was limited in this case to a single observer, and therefore was potentially subject to ethnocentric bias. However, the design of the study overcame this difficulty by obtaining data from several different countries.

As described in the methodology chapter, a number of experts were interviewed in the sample countries. These interviews with expert panel members were examined using issues analysis since the time available did not permit a full coding for software such as NVivo or NUDIST. The first scan of the material sorted it into categories related to the research questions, with subsequent scans identifying groups of issues within each of these categories. These were analysed using the procedure of constant comparison (Glasser & Strauss, 1967, p.104). For ease of reading, references to specific sections of expert panel interviews have been coded in this chapter. Thus TE186 refers to the 186th interaction in the interview with expert panel member TE.

The school case studies were drawn from the sample countries and Australia. The Australian case studies were included to widen the scope and range of information available. Students in the case study schools were mixed in gender and ranged from six to eighteen years of age. The smallest school had an enrolment of 430 students (Pärnu Nüdupargi Gümnaasium, Estonia) while the largest had 1839 (South Eugene High, USA). Generalisation through time-series analysis was not possible as each school was visited only once, but cross-case comparison analysis was performed using the pattern matching technique (Burns, 1997, p. 378). Since each case study used the same basic format, this allowed information to be drawn from each case in a

systematic way which permitted comparisons to be drawn and patterns between the cases to be identified. This was combined with explanation building (Burns, 1997, p. 379) to iteratively determine current and emergent practices.

4.2 The nature of policies for ICT in school education (RQ1a)

In 1999 the countries had diverse backgrounds (Appendix 6.11). Estonia had declared unilateral independence from Russia in 1991 through a ‘singing revolution’ (see Appendix 6.8), and was in a process of transformation. The country was rapidly increasing the use of computers in school by means of two main projects. The first (named ‘Tiger Leap’) was internally funded, distributed hardware to schools and promoted its curriculum uses. The second (PHARE-ISE) was externally funded by the European Union and was principally concerned with ICT-based administration systems for schools. There were areas common to both projects, such as the preparation of digital curriculum materials.

England had changed to a Labour government after 18 years of Conservative rule in 1997, and was implementing many changes in education and other policy areas. The situation was dominated by the National Curriculum and a more recent targeted training program for teacher ICT skills funded through the new National Lottery (New Opportunities Fund, 2002).

The USA was the world leader in gross domestic product and GDP per capita. The Federal government had quadrupled its normal funding levels to selectively increase the use of computers in schools. National, long-range policy for ICT in education was expressed in *The Technology Literacy Challenge* which considered computers as the ‘new basic’ (Office of Educational Technology, 1996). One of the targeted grants programs devised in support of this selective policy was *Preparing tomorrow’s teachers to use technology* (Department of Education, 1999), which contributed US\$1.5M of the US\$4M required to write standards for evaluation of student and teacher ICT use (DM107).

4.2.1 Teacher ICT skills policies

4.2.1.1 Rationale and status of national teacher ICT skills policies

The principal policies for teacher ICT skills in the three countries were as follows:

- Estonian skills requirements for teachers (Appendix 6.8.5)
- Annex B of Circular 4/98: Requirements for courses of initial teacher training (Department for Education and Employment, UK, 1998)
- ISTE Recommended foundations in technology for all teachers (International Society for Technology in Education, 1996) [USA].

Using the process for content analysis outlined in Burns (1997, pp. 338-342) the documents were coded to identify themes, content and meaning. Summaries of categories were made for each document, which were then compared. The first clear finding related to the rationale and status of each policy document. These are shown in Table 8, and an example of the coding from which it derives is given in the Appendix, section 6.12.

Table 8: Status and rationale of teacher ICT skills policy documents

	Estonia	England	USA
Rationale for ICT in education	Social Economic	Pedagogic	None stated
Status of teacher ICT skills policies	Mandatory	Mandatory	Advisory requirements for NCATE approved institutions

The reasons for the discrepancies between the rationales and statuses of the policy documents lie in the governance structures and recent histories of the sample countries. In Estonia, the relatively recent advent of democracy was the justification for an equal emphasis on the social and economic rationales (Appendix 6.8; Hawkrige, 1989). This was demonstrated by linkage to national ICT policy, which was considered of the utmost importance: “Information policy is an integral part of public policy” (Estonian Informatics Centre, 1997, para. 1) and was perceived as a guide to the “creation of an information society”. ICT had the capacity to eliminate barriers to equality by delivering services to everyone irrespective of location and was therefore expected to “promote and ensure democracy in the Republic of Estonia” (para. 9) and would have an important role in “sustainable economic development”

(para. 19.1). The educational aspect of this policy provided professional development to teachers and computer equipment for schools through the Tiger Leap Project (1999), giving them operational computer training equivalent to the ECDL (European Computer Driving Licence), in line with the mandatory requirement to have these skills. Thus the social rationale was the emphasis in Estonia. Hope for ICT enabling change in society was tempered by a rigid curriculum based upon highly defined time allocations for each subject (EM46). The constraints of a curriculum established prior to ICT were seen as a barrier to adoption, as in other countries (NM6; DM4). There was particular evidence of students being restricted in their use of ICT in the last years of secondary schooling because of the pressure to study for terminal examinations (MR133; TE54).

By comparison, the rationale and status of the teacher ICT skills policy in England is starkly different. The policy is expressed in the form of a Circular from the Department for Education and Employment to all initial teacher training institutions. The language used is direct, with the word ‘must’ in five of the six introductory sentences. The rationale is clearly pedagogic, which would be expected to appeal to the audience: “ICT is more than just another teaching tool. Its potential for improving the quality and standards of pupils’ education is significant” (Department for Education and Employment, UK, 1998). The analysis of the policy is shown in Appendix 6.12.1. This pedagogical rationale derived from the concept of differentiation, where ICT is used to allow students to progress at their own individual rates through learning material (BM21). IT was made a core subject alongside literacy, numeracy, religious education and science (MR125).

In the USA, the rationale for ICT in the national plan was shrouded in phrases such as “for the purpose of achieving excellence among our students” (Office of Educational Technology, 1996), which blends the pedagogic and economic rationales indecipherably together. Jarboe (2001) makes it clear that the shift to a knowledge economy was considered a vital national transition, and therefore much of the rhetoric associated with the educational documentation needs to be considered in that light. Although no specific rationale is stated in the policy for teacher ICT skills, the introduction to the national plan is replete with rhetoric such as “if we help all of our

children to become technologically literate, we will give a generation of young people the skills they need to enter this new knowledge- and information-driven economy” (Office of Educational Technology, 1996). It is therefore reasonable to deduce that the emphasis in the USA was on the economic rationale.

The expert panel evidence made it necessary to separate the economic rationale into two very distinct areas, one pertaining to all general employment, and the other specifically related to the production of ICT products and services. The first area related to the benefit accruing to individuals in their working lives from ICT skills learned at school (MR53, 65, 69; TE68). “It would be a feature of mass employment” (NM50). The general employment area was also linked to school subjects where ICT was integral to the subject matter, such as CAD/CAM (MR11). However, there were elements of the curriculum which related specifically to ICT products and services, such as micro-electronics and control technology. This hardware aspect of ICT, was unique to the English national curriculum and was compulsory for all students. It related to the other area of the economic rationale where national prosperity hinged upon competition in the global market for ICT-related intellectual property (MR31, 61; NM53-56). There was little evidence of this second area of the economic rationale having justified itself, possibly having been in operation for too short a time (MR127).

The three sample countries therefore displayed the three rationales for ICT in education quite clearly, with a social emphasis in Estonia, a pedagogic focus in England, and a probable economic stress in the USA. The pedagogical rationale was referred to by experts from all the sample countries (DM76; BM21; EM59). The question of the technology trajectory (Bijker & Law, 1992) or the role of ICT as ‘driver’ or ‘tool’ (Venezky & Davis, 2002, p. 31) can be examined in the light of these rationales. The social and pedagogical rationales align with the use of ICT as a tool for already defined purposes, which would therefore indicate an integrative approach in education. The economic rationale accepts the necessity to adopt ICT as a driver for change, and therefore points to a transformative approach.

An important understanding associated with general policies for ICT in school education was the need to update them on a regular basis (DM46). None of the sample countries had institutionalised such a revision cycle, although England had in practice done so every five years (BM89). There was evidence of a contradiction between policies in England, where a popular emphasis on ‘the basics’ (of literacy and numeracy) with mandatory allocated class time and a whole-class teaching philosophy were contrary to the differentiation approach inherent in the pedagogical rationale for ICT integration (BM 143).

4.2.1.2 Contents of national teacher ICT skills policies

In the body of the policy documents, expectations of teacher ICT knowledge, skills and attitudes were expressed in detail. Three categories of these attributes emerged from the content analysis:

- Those relating to the personal operation of a computer system by a teacher: the personal operational ICT skills
- Those relating to student use of computer systems for learning under the direction of a teacher: the teacher ICT instructional fields.
- Those relating to the context of computer systems in education: the pedagogical ICT skills.

Each of these three categories is cross-nationally compared in the following sections.

4.2.1.2.1 Teacher personal operational ICT skills in national policies

The first of these categories was analysed with respect to explicit mention of particular teacher knowledge, skills and attitudes. A number of sub-categories was identified and the incidence of these is tabulated in Table 9.

Table 9: Teacher personal operational ICT skills

Skills, knowledge and attitudes of the teacher in respect of personal operation of a computer	Estonia	England	USA
Operational [eg. operate a multimedia computer system using correct terminology]	✓	✓	✓
Publishing [eg. word processing, desktop publishing, multimedia presentations]	✓	✓	✓
Communicating [eg. e-mail, audio/video conferencing]	✓	✓	✓
Researching [eg. access information, data collection, information management]	✓	✓	✓
Problem Solving [eg. decision-making, spreadsheet applications]	✗	✓	✓
Independent learning [eg. identify computer and related technology resources for facilitating lifelong learning (USA)]	✗	✓	✓
Social impacts of ICT [eg. demonstrate knowledge of uses of computers and technology in business, industry, and society]	✓	✗	✓
Occupational health and safety with ICT [eg. is aware of the-dangers of using ICT-to his/her health, social and mental development]	✓	✓	✗
Legal & Intellectual property aspects of ICT [eg. demonstrate knowledge of equity, ethics, legal and human issues concerning use of computers]	✓	✓	✓

The data show there was a strong similarity between the sample countries in terms of what they wanted teachers to know and be able to do for themselves using ICT. There was explicit mention of particular skills such as “using menus, selecting and swapping between applications” (Department for Education and Employment, UK, 1998). Some differences between countries were noted in the area of independent learning where reference was made to the use of ICT for “lifelong learning” (USA) and to improving “their own professional efficiency and to reduce administrative and bureaucratic burdens, including ... how ICT can support them in their continuing professional development” (England). This indicates some tension within this category.

4.2.1.2.2 *Teacher ICT instructional fields in national policies*

The second analysis category related to teacher skills when applying ICT in the learning process. These sections of policy documents described the teacher skills required for the application of ICT to support instruction at each grade level and in subject areas. The policy documents indicate that the teacher is expected to instruct students to use computers in particular ways and that they should be taught particular knowledge related to ICT. The explicit incidence matrix of these ways and knowledge is given in Table 10.

Table 10: Teacher ICT instructional fields

How teachers should instruct students to use computers and the ICT-related knowledge they should be taught	Estonia	England	USA
Operational	✗	✓	✗
Publishing	✗	✓	✗
Communicating	✗	✓	✗
Researching	✗	✓	✗
Problem Solving	✗	✓	✗
Independent Learning	✓ create materials for student independent work	✓ diagnosis, ILS, online learning	✓
Social impacts of ICT	✗	✗	✓
Occupational Health and Safety with ICT	✓	✗	✗
Legal & Intellectual property aspects of ICT	✗	✗	✓

In this category the incidence matrix is far sparser. There are two possible explanations for this. One explanation might be that these skills are to be found in a complementary policy describing the ICT-related skills students should acquire. Another explanation is that the teacher is expected to inculcate his/her own personal and professional ICT skills, knowledge and attitudes (from the previous category in Table 9) into students. It can be argued that this is not an appropriate view by giving a short example. A teacher may be personally proficient with a word processor and able to use all its functions. A most important function is the ease with which text can be

invisibly edited. However, the pedagogical implications of this provisional nature of information using ICT are not immediately transferable to supporting the curriculum. Therefore the pedagogical skills required of the teacher instructing students through the use of a word processor go far beyond the mechanical operational level of word processor function. This implies a need for teacher ICT skills policies to relate closely to student ICT skills policies, a requirement not present in those examined here.

4.2.1.2.3 *Teacher pedagogical ICT skills in national policies*

The final category in the analysis of these teacher ICT skills policies related to the general context and management of computer systems in school education. This generated just four sub-categories. The incidence matrix for these is in Table 11.

Table 11: Teacher pedagogical ICT skills

Teacher skills	Estonia	England	USA
Evaluation of digital content	✓	✓	✓
Pedagogy	✓ group work	✓ Decide using 4 criteria when and when not to use ICT for teaching. Know how to use ICT for students with special educational needs	✓ Apply computers and related technologies to support instruction in their grade level and subject areas... awareness of resources for adaptive-assistive devices for students with special needs.
Planning	✗	✓	✓
Infrastructure	✗	✓ set up simple ICT devices	✓ use and troubleshoot peripherals

The important issue of appropriate pedagogy is addressed in all three documents, but there was no uniform approach across the three sample countries. Teachers in Estonia are expected to know “the principles and methods of ICT-based active- [activity?] and project [-based?] learning”. In England, there is an explicit focus on the need for teachers to “make sound decisions about when, when not, and how to use ICT effectively in teaching particular subjects”. This aligns with the focus of the English

policy, which prioritises improved subject teaching over ICT application. By contrast, in the USA teachers are expected to “apply computers and related technologies to support instruction in their grade level and subject areas”. Despite this lack of uniformity about pedagogical approaches, the policies assume and support integration of ICT into current classroom practice, with the intention that ICT be used to support the existing curriculum. This confirms the finding of the literature review about the current policy focus on integration.

4.2.1.3 School level ICT policies

School ICT coordinators appeared to play a significant and sometimes dominant role in formulating school-level ICT policy. At Pärnu Nüdupargi Gümnaasium (Estonia), a single teacher was held responsible for devising the ICT integration curriculum which was subsequently followed by the rest of the staff. Since this was done without reference to external advice, there was a risk the curriculum would be out of step with local community or national norms, but this was not evident at the time of the case study. Tadcaster Grammar in England represented the opposite extreme, with school ICT policy developed by an inter-departmental working party informed by the national curriculum requirements. This combination had extensively documented policy expectations and implementation strategies so that ICT was integrated into all subjects and student progress was monitored extensively.

Given these extremes, the role of the ICT coordinator can be examined in greater detail. The Estonian example above illustrates how a single change agent can be instrumental in assisting the diffusion of an innovation. However, in South Eugene High, it was clear that the change-agent role could also become one of gate-keeper. This was evident from the way in which the researcher’s initial enquiry about ICT policy was interpreted as a question about Internet safety.

School ICT policy also needs to be considered in the context of other policies to which the school is held accountable. In the sample countries there was a variety of national, regional and local policy formation mechanisms of which teachers were aware. BJ (South Eugene High, USA) perceived the school response to these policy

sources as strictly proportional to their funding contributions. Therefore the national (NETS) standards were not known about or used in the school since federal/top-level government did not make a significantly large contribution. By contrast, the Certificate of Initial Mastery and College entrance tests were important instruments governing the way the school was run. Additionally, the teachers in nearby Theodore Roosevelt Middle (USA) felt 'burned out' by the continuing stream of policies in almost every area. This was echoed in Winthrop Primary (Australia) where the Curriculum Improvement Program had supplanted ICT as the funding and priority focus.

4.2.2 Student ICT skills policies

The principal policy documents used for this analysis were as follows:

- Estonian skills requirements for students (see Appendix 6.8.6)
- The three versions of the National Curriculum (HMSO, 1990; Department for Education, 1995 and Qualifications and Curriculum Authority [QCA], 1999)
- National Educational Technology Standards for Students (International Society for Technology in Education, 1998)

The content analysis of the policy documents was conducted as before (Burns, 1997, pp. 338-342). The student ICT skill policies were similar to those for teacher ICT skills, therefore the sub-categories generated are similar, but not identical. There were many areas of commonality between the countries, as shown in Table 12.

Table 12: Analysis of student ICT skills policy documents

	Estonia	England	USA
Status	Passing subject (not optional) for school leavers	Mandatory foundation subject at all ages	Advisory for all ages
Rationale	Economic, social and ethical	Performance comparison	Parental, economic, social, national leaders
Curriculum application	Single subject	Cross curriculum	Cross curriculum
Age level	School leavers	All ages	All ages
Operational skills and ICT vocabulary	Graphical interface, filing systems	✓ information as text, images & sound	✓
Social, ethical, moral and legal issues	✓	✓	✓
Publishing and creativity	✓	✓	✓
Research and organisation of information	✓	✓	✓
Communication	✓	✓	✓
Problem solving and predictive simulations	Statistical analysis	✓	✓
Independent Learning	✗	✗	✓
Critical discrimination of digital resources	✓	✓	✓
Use micro-electronics for monitoring and control	✗	✓	✗
Create ICT systems for others to use	✗	✓	✗

Given the close similarity between student ICT frameworks for these countries (and others, see Table 33 in the Appendix), the following analysis concentrates on the aspects which make each one different. The Estonian student ICT skills policy was unlike the others because it focused upon ICT as a separate subject and was restricted

to school leavers rather than students in all years of schooling. The only explicit mention of problem solving skills was in respect of statistical analysis.

The National Curriculum in England had evolved through three versions in which ICT was initially a component of the Design and Technology subject expressed as a capability to be developed through a range of curriculum activities. It then became a subject in its own right, and finally in the 2000 version, a non-core foundation subject as well as a general teaching requirement in all other subjects (the other general requirements covered inclusion, occupational health and safety and [English] language [/literacy]). A particular feature of this student ICT skills policy was the emphasis on micro-electronics and robotics applications at all ages, and the opportunity for students to create ICT systems for others to use.

The unique element of the policy in the USA was the inclusion of ICT for independent learning. This incorporated “use of technology resources for self-directed learning” (Grades 3-5) and the “evaluation of technology-based options including distance and distributed education, for lifelong learning” (Grades 9-12). Independent learning represented an interesting exception to the homogeneity found in most other respects. Although expert panel member DM had suggested some people involved in the framework project in the USA accepted the potential for ICT to support independent learning by using the computer as a tutor, the majority had opted for agreement at a lower level which did not have industrial implications or threaten teacher’s jobs. Similarly, BM in the UK had pointed out the conflict between whole-class instruction policies for “the three Rs” and those policies for ICT which promoted differentiation to make learning student-centred (BM143).

When comparing the student ICT frameworks with the teacher skills relating to student use of ICT (Table 10), there is very little similarity between the two sets of results. This lack of alignment varied from country to country, but was an important feature of the data.

4.3 The development of policies for ICT in school education (RQ1b)

The evidence from the expert panel points directly to a four-stage process for policy development and implementation. This process starts with inspiration which is turned into a vision through policy development. The vision has to pass the test of practical implementation in schools before problem areas are identified.

US vice-president Al Gore was mentioned as a source of inspiration for all the sample countries (BM21; TE72-74; DM36; Gore, 1994b). In the USA this source of inspiration answered the challenge of the ‘Nation at Risk’ report of 1983 which said that “if our educational system had been inflicted upon us by a foreign power we would have revolted against it” (DM3). Education had attracted political support in the 1990s (DM36), and ICT represented an important part of this attraction (KB155). ICT was also the focus of government modernisation programs (BM120-126) and “open government issues” (Estonian Informatics Centre, 1997). This concept of ‘openness’ was sometimes viewed as a way of disguising centralisation as devolution (MR101 & 113).

The vision emerging from this original inspiration was sometimes held back by traditional beliefs. The first drafts of the national curriculum in England were rejected by Ministers because it was said “there is not enough knowledge in this, there are not enough facts in this” (MR53). Similarly the ‘new’ 1997 curriculum in Estonia was still dominated by knowledge of facts (EM46) and the immutable allocations of classroom time for existing subjects (EM56). The vision of the curriculum planners for the first iteration of the national curriculum in England was unlikely to have been clear (KB105) since no IT teacher sat on the technology committee which crafted the ICT section (NM10). This committee and its successors found it expedient to confound the various rationales for ICT in school education, to solicit support from the widest political spectrum (NM50+56). There was tension between policy and practice as a result of this lack of clear vision (NM14-15), both at the level of ICT and at a broader level because the national curriculum subject writing groups did not inter-relate (MR19). This has left ICT in dispute as a discipline, because it is not clear if it is an organic whole, or a “bag of bits” (NM34). Some argued that ICT is more than the use of software packages, and is a capability learned by thinking critically about

practical applications and using it to achieve learning outcomes for particular subjects (MR123).

The processes of implementation reflected this confused vision about the place of ICT in the school curriculum. Despite the general requirement that IT be taught across all curriculum areas (NM22; BM16; TE68), some schools provided separate ICT training sessions for all students since implementation was a school-based decision (KB83). This practice and climbing licensing costs had collapsed the range of software used by many students to generic office applications (KB107). The Stevenson report in England (The Independent ICT in Schools Commission, 1997) had emphasised the pedagogical rationale incorporated into the 2000 version of the national curriculum (NM114), but this had to be exemplified through schemes of work to translate it into a form teachers could understand and use (NM182). This articulation of policy into practical terms for implementation was also found in the USA where they were clearly aimed at integrating ICT into current practice, showing how the existing curriculum could be supported through the use of generic tools (DM82). NM argued that these exemplification materials were much more important to teachers than the policies themselves, and should have been presented in an attractive, disposable form, distributed together with the national curriculum requirements which should have been plain by comparison (NM192 & 204).

The experts were able to identify some significant problem areas associated with the processes of policy development and implementation. The lack of national coordination of many significant ICT projects for school education in England was cited (BM103 & 110) as a major concern. In Estonia, the most significant obstacle to ICT adoption was finding software in the local language (TE57 & 58). This persists for subject specific software but the suggestion to create an Estonian version of OpenOffice was taken up with “an Estonian spellchecker and hyphenation engine... ordered and paid for by the state” (TE59-60; Veenpere, 2002). The availability of online translation engines had been exploited by students to facilitate their foreign language homework (TE200).

This evidence about policy development and implementation stresses the importance of a clear vision for ICT in school education. This needs to emerge from cross-disciplinary and project coordination, and has to be effectively communicated to teachers in a way that corresponds with their existing knowledge. Since curriculum software used once a year and generic office packages which are used for many hours a day cost about the same, there is a significant resourcing barrier for subject teachers trying to adopt ICT. This barrier needs to be addressed through actions such as centralised government sponsored production of topic-specific materials or through copyright legislation to permit application rentals based on hours of use rather than operational copies available.

4.4 The relationship between government inputs and the use of computers in schools (RQ2)

In general, the expert panel identified government inputs to be curriculum frameworks, evaluation and targeted resources as the instruments by which school education was most influenced. There was mandatory curriculum inclusion of ICT in England (BM 8/10; NM4) and Estonia (TE68). This was also true at the state level in the USA, but the federal government had influenced the nature of this curriculum indirectly by sponsoring the non-profit organisation ‘International Society for Technology in Education’ (ISTE) to develop the national standards for teacher and student ICT skills that were subsequently adopted with minor variations by states and school districts (DM23). Various devices were used by the federal government to encourage this adoption, such as making targeted funding derived from socio-economic equity funds preferentially directed to ICT in line with the standards (DM4). Additional government inputs were in the form of government information published through a web-site (DM9; <http://www.ed.gov/free/> Federal resources for educational excellence). The equivalent interconnecting resource in England was the National Grid for Learning (NM182; MR185; <http://www.ngfl.gov.uk/>) and in Estonia the Koolielu Teacher’s Net (<http://www.opetaja.ee/>).

Implementation of ICT-related curriculum frameworks was easier in primary schools because “the teachers have more time to use IT”, and it was argued that resources should therefore be directed preferentially to this sector (TE128). The other important

influence government had on computer use in school education was through evaluation. An example was given where poor state-wide student performance on standardised tests of literacy and numeracy was successfully responded to by the installation of ICT in every classroom (DM76). However, there was a policy anomaly in England where student ICT skills themselves were not assessed through national testing, even though this was done in the other core curriculum areas of English, Mathematics and Science (KB89).

4.4.1 Resources and their disposition

The smallest number of students per computer was 4.5 (Applecross Senior High, Australia) whilst the largest number was an order of magnitude greater (Lyceum Descartes, Estonia). Across the case studies 15 percent to 95 percent of students had access to a computer at home. The comparison in Table 13 shows that in every case study school, home access to computers was higher than in school.

Table 13: Number of home computers for each school computer (by case)

Case Study	Number of student accessible computers at home for each computer at school
Theodore Roosevelt Middle School (USA)	5.7
South Eugene High School (USA)	13.3
Lyceum Descartes (Estonia)	6.7
Pärnu Nüdupargi Gümnaasium (Estonia)	6.2
Tadcaster Grammar School (England)	6.7
Applecross Senior High School (Australia)	3.8
Winthrop Primary School (Australia)	5.8

With the comparative data expressed in this form, it becomes clear that the differences between cases are far smaller for this criterion than the order of magnitude differences between cases in respect of computer access inside school. In-school access was differentiated along the lines which could be predicted by national GDP, with schools in the USA having many more workstations available than schools in Estonia, in concurrence with the findings of Dodge (1998, Figure 3a). When the focus is switched to home computers, it can be seen that there are pro-rata many more of these in every case, whichever country the school is in. At the least, there are 3.8 home

computers for every school computer (Applecross High, Australia). The figures for the Estonian schools (cases 3 and 4) are in the middle of the range. This shows a pattern across all countries, which might be extended beyond the sample schools themselves, provided the sample was not biased towards a particular socio-economic grouping. This result was generalised using published data on home computers for households with children or percentages of children with access to a computer at home. Using data from the literature review, the case studies and other published sources, the relevant figures are shown in Table 14.

Table 14: Extrapolation of home:school computer ratios

	Estonia	England	USA	Australia
Students:computer (see Appendix 6.11)	28	7.7	6	12
Therefore: school computers per 1000 students	36	130	167	83
Fertility rate ¹	1.21	1.73	1.9	2.21
Households per 1000 students	826	578	526	452
Proportion of households with children which have a home computer ²			70%	74%
Proportion of school children with access to a home computer ³	17%	61%		
Therefore: home computers per 1000 students	150	610	700	334
Therefore: home:school computer ratio	4.1	4.7	4.2	4.02

¹ Globaledege, 2002; Siena Group, 1999 ² Lewin, 2001; Australian Bureau of Statistics, 2000d ³ Case studies (Estonia); National Statistics, 2002, p.22

Many of the ICT coordinators were concerned with ICT infrastructure. The case studies illustrated two problematic resource issues. The first appeared on the surface to be simplistic, yet was not. This was the issue of bandwidth, and in particular the speed of the connection between the school, the Internet and other schools. The reported speeds varied from an ISDN line at 64kbps in Tadcaster Grammar (England) and Pärnu Nüdupargi Gümnaasium (Estonia), to 1Mbps or better at Lyceum Descartes (Estonia) and Theodore Roosevelt Middle (USA). The supposition that more is better was not entirely valid, since student safety policies interfered with access to the bandwidth. Internet safety policies had resulted in the disabling of the internet protocol on many student workstations because they could not be constantly supervised by a responsible adult (South Eugene High, USA). This raises a question

about the appropriate metric for judging the adequacy of such bandwidth; whether it should be measured per student capita, per workstation, or per TCP/IP enabled workstation.

The second infrastructure issue dealt with the disposition of computers around the school, with arguments for and against classroom and laboratory emphases. Winthrop Primary (Australia) had chosen an intermediate strategy by putting two computers in each classroom and a mini-hub of six further workstations to be shared between four classes. Other examples were at Applecross Senior High (Australia, Figure 24) and Theodore Roosevelt Middle (USA, Figure 11) where some teaching spaces had up to eight workstations. Where school computers were concentrated into laboratory teaching spaces, this was on the basis of providing whole-class instruction specifically on ICT. Some laboratories incorporated the design principles of dual seating positions for each student and a single focal/demonstration point for the teacher. The dual seating positions allows one for work on the computer, the other for group instruction and collaborative planning/conferencing. The single focal point allows the teacher to observe all student screens during the lesson, or to maintain eye contact with students while demonstrating. Compare Lyceum Descartes, Estonia (Figure 17) with Tadcaster Grammar, England (Figure 22).

4.4.2 Examples of practice

Stemming from this issue of workstation deployment came the more significant matters of the location of learning and the location of teaching. The integration of ICT into school education means this can no longer be taken to imply the classroom as a specific place where these activities coincide. The case study data were analysed in three ways to illustrate this point. Firstly, the data show how digital materials created within the school are becoming part of classroom practice; secondly, digital materials created outside the school are being incorporated into student learning; and finally, there is evidence of the increasing use of digital communications to link classroom-based student learning with external sites, including homes.

Examples of internally produced learning activities were the texts and crosswords used at Pärnu Nüdupargi Gümnaasium (Estonia), the library of landform images and

the information systems course on the intranet at Applecross Senior High (Australia). Each of these demonstrated an increase in differentiation, allowing students to proceed through the teacher-directed learning activities at their own rate. Another way of promoting a degree of student autonomy was given by the use of a generic learning support package *Studyworks* to encapsulate mathematics lessons into independent learning modules at Lyceum Descartes (Estonia). This extended the idea of internally produced digital materials to a collaborative effort between teachers at many schools who produced self-study tutorials. Another example of multi-site collaboration was found at Theodore Roosevelt Middle (USA) where the students experienced a geometric mystery created by their predecessors before creating their own contribution to a globally accessible learning resource.

Externally produced learning activities included the downloaded graphics calculator tutorials and interactive mathematical activities referenced by HB at Applecross Senior High (Australia) and the *Quizzard* example from Winthrop Primary (Australia). In the USA, students were observed using commercial software such as 'Age of Empires' and accessing astronomy web-sites. Each of these examples showed a different teaching technique to integrate these published resources into classroom practice, sometimes with a teacher-produced worksheet as a scaffold for students. In this respect the externally created digital resources could be viewed in the same way as any other learning material brought into the classroom. However, students and teachers at the case study schools attested to the greater motivation for learning from inter-active materials and the increased learning attributed to interaction with off-site teachers or co-learners.

The e-mail based simulations observed at Lyceum Descartes (Estonia) were illustrative of the role of ICT-mediated communications. Attempting to correct an unbalanced ecology in the Gaia simulation, the decisions each student group made were collected centrally and matched with the model, facilitating collaboration and competition between several schools. Working collaboratively, the students at Applecross Senior High (Australia) were able to build their web-site on petroleum from school but to a greater extent, from home. ICT was expected to increase the role of the home at South Eugene High (USA) and Winthrop Primary (Australia) through

third party commercial ventures or government projects. Applecross Senior High (Australia) made reference to Virtual Private Networking as a tool which was projected to incorporate student home computers into the school information management system. However, a major concern in many of the case study schools was that of the 'digital divide' (Knobel, Stone & Warschauer, 2002, p. 3) where local policy failed to integrate home computers because of the lack in some student's homes. Even where this had been considered, the issue of compatible file-formats between home and school had been a barrier to development. There was evidence that online courses were being used to extend the number of optional subjects students could elect to take, and this study-mode was expected to be a feature of education beyond school (Theodore Roosevelt Middle, USA).

Eight of these eleven examples were the product of individual teachers working with their own classes. Very few examples of whole school involvement were found, but these individuals were obviously taken as exemplars since they were invited by their schools to be observed for this study. These individuals at the leading edge appeared to rely on intrinsic rewards for this work. HB at Applecross Senior High (Australia) said that personal altruism was the only motivating principle behind his personal integration of ICT into classroom practice. It therefore remains debatable as to how long that motivation will remain if unsustained by other factors supporting innovation diffusion.

4.5 Professional development (RQ3)

4.5.1 Objectives of teacher ICT training

Professional development was a form of government input separated out for special consideration in this analysis because of its importance. It was common to find that standards were initially written for pre-service teacher training (DM33; MR191) but the responsiveness of these institutions was perceived as too slow to meet systemic needs (EM1). The standards were therefore transferred to the in-service context (KB21; DM34). The most important barrier to this transfer was the professional fears of teachers expected to work with students who know more about ICT than

themselves (EM64 & 66; KB151) and university graduates could not meet the ICT skills standards for Year 8 students (DM 15 & 17). These professional fears were so significant that teachers chose not to use student-accessible workstations for developing personal ICT skills (TE184). In England ICT professional development was promoted to qualified teachers by advertising and linkage to career progression (MR195). The standards were published with teaching applications preceding personal ICT skills (MR211) to focus on subject teachers' interests rather than the technology (MR239). Applying the differentiation philosophy to the process itself, a CD-ROM was produced to help teachers identify their personal ICT training needs (MR231; KB25-20; BM38) prior to booking courses provided through a competitive market (BM32 & 33). This was the country's largest-ever professional development project (BM27), with top-level decisions in government allocating £230 million to it (BM27; KB57). The objectives of this training were confused, according to a major provider (BM36).

There was poor alignment between teacher ICT professional development standards and curriculum expectations for students. In the first part of this chapter it was shown that the modal incidence matrices for teachers and students were very different. In England it was very difficult to link professional development and pupil curriculum frameworks because they were the provinces of two different organisations (KB11), and consequently were not well matched (KB163). Professional development in Estonia was expected to drive curriculum change at the personal level of the teacher, since institutional change would take far too long (EM89). It could be argued that the confusion about training objectives stemmed from this mismatch between what teachers were taught and expected student outcomes. One expert put it as “the difference between ‘using ICT’ and ‘teaching IT capability’ ” (MR121). A similar confusion was observed in classes where students thought they were learning to use ICT but the teacher assumed they were learning subject topics through ICT (KB59). The distinction point where the technology vanishes into the background comes when individuals have mastery of the medium. Therefore the assessment of the English professional development project was done on the quality of teacher decision-making about when and when not, to use ICT (KB137), rather than classroom practice. It was

argued that assessment could therefore only be done using authentic situations, not online drills (TE148).

4.5.2 Accountability and amount of ICT professional development

Accountability for professional development observed in the case-study schools showed a progression from it being considered a personal concern of each teacher, to an internal school matter and eventually a country-wide supported and mandated project. ICT professional development was considered a personal matter for each teacher in Theodore Roosevelt Middle (USA) for registration purposes, and also at Pärnu Nüdupargi Gümnaasium (Estonia). This personal responsibility was similarly expected at South Eugene High (USA), but was internally supplemented by “a couple of seminars every year, trying to induce older teachers to come in and start experimenting” (BJ6). At Winthrop Primary (Australia) the principle of ‘just in time’ training was used to provide support within the school (SP28). Applecross Senior High (Australia) used a similar in-house process which was monitored by an annual staff skills survey. The school also participated in a systemic initiative providing notebook computers to teachers. These local/regional approaches were significantly different from the national training projects affecting Tadcaster Grammar (England) and Lyceum Descartes (Estonia). The English scheme focused strongly upon the integration of ICT into classroom practice, whilst the PHARE-ISE project in Estonia utilised external consultants to deliver software-specific training.

The cost of formal European Computer Driving Licence (ECDL) accreditation was too high for Estonian teachers (TE138) but this was used as the framework for their forty-hour courses (http://www.tiigrihype.ee/eng/noukogu_otsused/otsus.html; EM1). In the USA more than twelve hours a year were deemed necessary to stay current with the operation of office packages (DM84) with 15-30 percent of state ICT funds allocated to such training for teachers (DM60). Courses in England required teachers to already have these basic skills and access to defined levels of school equipment (BM26) before they could undertake subject-specific training for forty to fifty hours (BM44).

The source of training in the case-study schools appeared to be strongly linked with the amount expected and the source of funding support for this. Where very little ICT training (typically a day per year) was expected of each teacher it was a personal or local school matter. National schemes in England and Estonia provided far more training, but differed in their uniformity of availability. From comments made at several of the case-study schools, training was only gradually overcoming teacher apprehension about ICT (BJ6, SP62).

4.6 Stages of development (RQ4)

4.6.1 Current stages

The expert panel members reflected upon (then) current policy and implementation. There was a clear understanding from the expert panel that ICT was mainly being used to support the existing curriculum, and thus current practice was at best integrative. Some schools were only able to support limited student access to computers, and this was generally restricted to ICT-related study (Lyceum Descartes, Estonia). Elements of later stages were present, but the lack of access for the majority of students and staff on a uniform basis made it impossible to take this into account when assessing the development of the school as a whole. This was also the case at South Eugene High (USA) and Winthrop Primary (Australia) where student use of computers was limited to a very small range of subjects. In England many schools thought the aim of the IT curriculum was merely to “learn keyboard skills, how to use a word processor, how to enter stuff into a database, surely? Fascinating stuff (sarcastically)” (NM64). Teachers were “using computers in this case to try and make sure a greater proportion of the students reach the current benchmarks” (BM72). In the USA the current standards were considered “mundane” (DM20). Observation of local schools revealed practice of very doubtful value: “The kids used computers for instance for word processing, they could play games if they got other work done” (DM60). Such comments revealed the dissatisfaction members of the expert panel had for the prevailing state of affairs.

There were barriers to ICT adoption. In the USA, there was opposition to the concept of computers supporting independent learning: “The people who put NETS [National Educational Technology Standards] together on average are anti-computer supported instruction” (DM67). In England accreditation was a barrier: “Examination boards deliberately legislate against the use of ICT. Even for course work for GCSE. It must be handwritten; you will not be allowed to submit desktop published material” (MR134). Key components of the policy, such as modelling, were difficult for schools to appreciate: “Nobody understood it” (NM72). Thus lack of widespread knowledge about the new ways of using ICT and system inertia were considered to be obstacles to innovation diffusion. Some teachers were “ostriches with their heads in the sand” with respect to ICT, and this was a considerable challenge for the ICT coordinator at Winthrop Primary (Australia): “I don’t water rocks” (SP62).

4.6.2 Future stages

The expert panel identified elements of current policy and practice which pointed towards the future. Some elements of the UK national curriculum could not be taught without a computer “computer aided design, computer aided manufacturing ... Things in our secondary Art where you look at people like David Hockney making extensive use of ICT” (KB195). Some schools had virtual classes with their learning materials online (KB199). Others had made sure 100 percent of students had home access to a computer, winning a national award in the process (MR144; Smithers, 2000). Internet links between home and school have the potential to replicate existing practice, or they could be used to transform educational processes (NM169). In Estonia new learning materials were being placed on the web (EM13) and were used to support distance education in biology because of the lack of specialist teachers (TE106 & 110).

There were factors the members of the expert panel considered important for future policy and implementation in this area. They saw the promulgation of ICT standards as a step on the road to “changing the purpose of education” (DM81). ICT changes the nature of student-teacher relationships (EM86). This is not the first time that popular understanding of the core school curriculum has changed, with ICT itself recently emerging as a completely new subject area (NM6). To put things into

perspective, the subject 'English' has only been available at degree level for 150 years: students previously had a choice of 'Greats' or 'Classics' (NM154), and like IT, is often taught across the curriculum (MR164). The evidence that the experts saw transformation coming was reinforced by opinions from Estonia that they had skipped stages of development, such as Macintosh computers (seen as an unnecessary distraction) (TE13), and had gone straight to broadband wireless Internet connections (TE80; EM115) and Unix servers in schools (TE174).

There was commonality of expert evidence about the expectation that ICT will bring educational transformation and consensus about the difference computers makes to learning environments. "Kid plus machine is different than kid" (BM75; Perkins, 1993; BM79) which is justified by research findings showing computer-based tools can facilitate the learning of high-level concepts in mathematics (DM20). Further evidence of expected change came from emerging disciplines, such as computational chemistry in the Nobel Prizes (DM21) and the increasing prevalence of new knowledge emerging from multi-disciplinary teams facilitated by ICT use. This kind of blended discipline activity is supported in schools by using ICT as a "penetrating" subject (EM9; DM81). The considerable potential of significant change was illustrated by equating the computing power used in 1994 for national weather forecasting with modern desktop workstations (DM82), the implication being that students can now undertake computational tasks of this order, but are rarely given the opportunity to do so. Another example was given in the area of foreign languages where ICT could facilitate the understanding of dialects through direct conversation with native speakers (NM146). At Applecross Senior High (Australia) there was evidence of significant change to learning processes, primarily through the use of local and external digital materials which could also be accessed from student homes.

Where the use of ICT was more widespread, it was not always instrumental in effecting significant curriculum change. This would be applauded by those who see it as a 'tool' with its use limited to adding interest and motivation to the existing subject matter (Theodore Roosevelt Middle, USA and Pärnu Nüdupargi Gümnaasium, Estonia). At Tadcaster Grammar (England) ICT was embedded in most subjects in meaningful ways, and these were bringing new areas of learning, impossible without

computers, into the classroom for all students. However, there was a limitation in the variety of ways ICT was incorporated into any one subject area, and the process of teaching and learning was little changed.

4.6.3 The road to transformation

It was clear that local factors dominated in the case study schools. Where a national policy existed, this could take a long time to filter through to classroom practice, as in Theodore Roosevelt Middle (USA), unless there was particularly significant funding associated with it *e.g.* Tadcaster Grammar (England). The Office of the e-Envoy, part of the Cabinet Office, had provided 98 percent of schools with internet access (Office of the e-Envoy, 2002). However, school access to the internet provided by this scheme was not as available to students as in their own homes, with 7.7 students per computer in schools compared to 45 percent of households having access (National Statistics, 2002: 2002b). The growing importance of home access was reflected in the change of ICT professional development from a deficiency model funded by the national lottery (New Opportunities Fund, 2002) to the supply of laptops to teachers (National Grid for Learning, 2001; 2002).

This was not to imply significant work could not originate at the local level, and individual teachers did make a huge difference as change agents, such as DM & KF at Theodore Roosevelt Middle (USA), HB at Applecross Senior High (Australia) and VT at Pärnu Nüdupargi Gümnaasium (Estonia). A common aspiration of these teachers who were transforming classroom practice through ICT was increased motivation and more autonomous learning for students. This was sometimes impeded from scaling to a school-wide basis by the very low number of computers available for student use, especially when compared to the home background. This access issue was compounded in some case study schools by laggard teachers who were reluctant to embrace the innovation (Rogers, 1995; SP62; BJ6). There was a difficulty of selection of digital materials for these and all teachers, who had to balance their understanding of *in loco parentis* when using the Internet to support independent learning strategies. In USA schools the former consideration had resulted in the disabling of Internet connectivity on many school computers. The latter consideration

had resulted in the ability of students to access learning materials from home being largely ignored.

4.7 Chapter summary

In this chapter the data have been presented. The following points have been made:

- Curriculum approaches for students were strongly aligned with a stage of development which emphasised integration of ICT into the existing curriculum and current classroom practice, and that
- These curriculum approaches tend towards an economic rationale for ICT in education when this policy is made subservient to national ‘knowledge economy’ policy.
- Achievement of particular benchmarks of school infrastructure and teacher training is a focus of the policies; despite the fact that
- These infrastructure benchmarks are already well exceeded in many students’ homes. Which makes it surprising that
- Models of teacher professional development are only now beginning to include ‘ownership’ as a strategy to overcome significant barriers to innovation and adoption. An awareness of these barriers shows us that
- ICT is being viewed increasingly as a ‘driver’ rather than a ‘tool’ in strategies for the creation of educational digital content, moving school education towards a transformative phase.
- Current practice is mostly focused on integrating ICT into the existing curriculum, with a tendency for collapse to the use of generic office applications
- There was a shared vision amongst the expert panel for ICT leading to transformation.
- Teacher professional development to integrate ICT into classroom practice takes forty to fifty hours initially and more than twelve hours a year thereafter.
- There was poor alignment between teacher training and student learning outcomes in the ICT area.
- Student access to computers outside school and their acquisition of ICT skills outside school far outstrips what is done in the classroom.
- Implementation is more strongly influenced by local factors than national policy.

- Individual teachers play a strong role in determining the degree to which ICT is adopted in the classroom.
- The ‘digital divide’ is rapidly shrinking, but few schools are publicly building on the home computers the majority of their students have access to.
- Professional development for teachers is limited (except in England) and is often restricted to software operation or to personal or school sourced skills.

In the following chapter these findings will be analysed to answer the research questions. In discussion, the analysis is used to develop and refine a new model for describing stages of development for ICT in school education.

Chapter 5 Discussion

5.1 Introduction

Data for the study was collected from 1999 to 2002. This chapter synthesises the findings of the study together with the research described in the literature review to answer the four research questions and consider three propositions about the future development of ICT in school education. The chapter describes how the findings were used to develop and propose a model of development for ICT in school education, and demonstrates its application to Australia. The chapter concludes with recommendations for action and for future research.

The research questions posed at the end of Chapter 1 have provided an organisational framework for this study. This section shows how the findings have confirmed, disconfirmed and extended previous research in the field of ICT in school education.

5.2 The findings in relation to the literature

5.2.1 Research questions 1a and 1b

Research Question 1a: What has been the general nature of policies in the USA, England and Estonia for ICT in school education?

Research Question 1b: What were the development and implementation processes of these policies?

5.2.1.1 Initial vision for ICT policy

The process of policy development according to the expert panel depended greatly upon an initial vision; in many cases attributed in the political sphere to vice-president Al Gore (BM21; TE72-74; DM36; Gore, 1994a) and referred to in the literature as the ‘Gore-effect’ (Klumpp & Schwemmler, 2000). In many cases there was political mileage to be made from education and ICT in particular (DM36), and having invested so much money in the area, many politicians are now politically unable to

withdraw support (KB155) which can be scheduled to peak as elections approach (BM24). Clarity of vision did not always persist in the writing process (KB105) and this political impetus for ICT in school education did not offer a clarity of vision or purpose that has persevered. This is partly due to the high rate of change of ICT technology (Bitter & Pearson, 2002, p. 1; Zakon, 1999) which makes policy review essential on a regular basis to address these previously unforeseen events (Dunn, 1994, p. 351). The expert panel and case studies confirmed the existence of a ‘technology push’ which was restricted by conservatism typified by an emphasis on student knowledge of facts (MR53, EM46) or an insistence that high-stakes examinations were conducted using hand writing (Plomp, Anderson & Kontogiannopoulou-Polydorides, 1996, pp.11 & 17; OECD, 2001, p.13; Eurydice, 2001, p. 19) despite most student day-to-day work being completed using a computer (KM60). It is unclear how policy-makers can best respond to this technology push; whether by constructing policies which are anticipative and adaptable, or by allowing for regular review and modification.

5.2.1.2 Pedagogical rationale

For ICT to get onto the agenda of national policy makers in education, it had to offer some advantage. The previous analysis of the three rationales (Hawkrige, 1989; Fabos and Young, 1999, p.218; OECD, 2001; Capper, 2003, p.63) is useful for examining the possible advantages which could be considered. The pedagogical rationale was difficult to justify with the research evidence in the literature indicating ICT has about the same impact as any other innovation (Parr, 2000). However, the expert panel and case study evidence (see Pärnu Nüdupargi Gümnaasium) partially confirmed the literature about ICT increasing learner autonomy (IAEEA, 1999) with this aspect of the use of ICT included in English policy and observed in Australian schools. Measures of ICT effectiveness were often confounded with ICT integration (Woodhurst, 2002), and concentrated on student learning outcomes against criteria established prior to widespread use of ICT which were not considered appropriate when ICT was a significant element of classroom practice (Fouts, 2000, p.5). The relevance of using existing curriculum benchmarks will be examined in the following section under Research Question 3. Not only is this issue crucial to the substantiation of policy purporting to assert the pedagogical rationale, it is also vital in the

justification and demonstration of ‘relative advantage’ for teacher professional development.

5.2.1.3 Social rationale

The social rationale embraced in Estonia is echoed by rhetoric about open government in England (Allan, 2000). ICT offers governments a very low cost way to deliver information and services to much of the population, providing telecommunications generally pre-existing, are available (Estonian Informatics Centre, 1997, para. 1). The open or modernising government movements have embraced ICT as a way to integrate policy in otherwise disparate fields, and through devices such as a ‘Citizen’s Charter’ clarify the services available and their cost structures (Cabinet Office, 2003). In education this rationale resonates with equity arrangements used to ensure all students have a fair and socialising upbringing. In the analysis of policy documents, the social impacts of ICT were components in the teachers’ personal skills (see Table 9 in section 4.2.1.2.1) for Estonia and the USA, and for all three countries in respect of student skills (see Table 12 in section 4.2.2). The analysis therefore shows that the social rationale is part of policy thinking in all three sample countries. It is also seen as important to policy in Australia as a pre-requisite for participation in society (Kearns & Grant, 2002, p. 11). This importance extends to the literature on lifelong learning and learning communities which promote social cohesion, and addresses solutions to the digital divide (OECD, 2000, p. 4; Dutta, 2002).

5.2.1.4 Economic rationales

The economic rationale appeared to be the most significant currently because of ‘knowledge economy’ strategies, and was shown in this study to embrace three distinct objectives. These comprised: generic ICT skills for all fields of work; more specialist IT skills for the production of ICT products and services; and also the need for economic efficiency within the education system itself. There is some concern amongst teachers that this new area of study is being imposed throughout school education without sufficient preparation or justification. Whilst schools do address specific workplace competencies in the latter years of compulsory education through vocational education programmes (Queensland Government, 2002, p.7), the

application of this approach from the earliest ages is in conflict with a general teacher culture of student empowerment and life preparation (Nuldén, 1999, p. 3).

Australia is implementing a pilot scheme testing student readiness to use ICT in the workforce from Grade 3 onwards (Varghese, 2002, p.2) which relates to the first objective in the economic rationale. Such schemes can appear to be impositions for which teachers are not ready (BJ29, BM26, KB19) and support the view that “schools are losing their monopoly on learning” (Hargreaves, 1997, p. 6). This objective within the economic rationale is seen by some teachers as a potential threat to their autonomy and emotionally unsettling, especially in the context of nationally centralised standards (KN83) implemented through self-managed devolved budgets.

The more specialised skills within the second objective relating to expansion of the ‘knowledge economy’ are only just beginning to receive particular attention. One example is the emergence of Victorian Information Technology Teachers' Association as a break-away professional association to specialise on IT disciplines alone, distinct from the ICT across the curriculum focus of its predecessor body (VITTA, 2003).

The study found that the first two objectives within the economic rationale were not supported in the case of Australia because students do not acquire ICT skills at school (Meredyth *et al.*, 1999b), and Australia has a large external trade debt in the ICT product sector (Australian Computer Society, 2002). The other possible economic advantage relating to the third objective, that of providing adequate teaching capacity within a restricted budget, has not received much public airing except in a few cases (Barber, 2000) or where there is an acute shortage of classroom places (McNulty, 2002). However, as was established in the literature review, the aging of the teaching workforce (Box, 2000, p.4; National Center for Education Statistics, 2000, Table 70) and the perceived relative cost advantages of ICT (Jurgensen, 1999, p. 16A) are no doubt significant factors in the minds of policy makers. The emergence of national policies for ‘the knowledge economy’ is a relatively recent phenomenon which has changed the direction of pre-existing policies for ICT in education (OECD, 2001b, p. 100). The consequence has been a considerable dislocation of initial focus and a

weakening in implementation, especially in the face of competing curriculum reforms (SP26).

5.2.1.5 Lack of policy cohesion

The existence of the three rationales and their relative weight over time has generated considerable policy uncertainty in the area. The English national curriculum illustrates this well, with the first version incorporating ICT as a sub-section of the Design and Technology subject area (economic rationale), the second identifying it as a separate subject to be addressed over all the other subjects (social rationale) and the most recent raising it to a core subject with cross-curriculum application (pedagogical rationale) (Qualifications and Curriculum Authority, 2002). This lack of policy cohesion has done nothing to make teachers secure in the belief that ICT has a place in the classroom. The data illustrated the way policy makers resolve this diversity, by framing ambiguous objectives which appeared to the proponents as representing each of their diverse views (NM50) or by formulating standards at the lowest common level (DM67, 82). National policies for 'the knowledge economy' were becoming more important, but as they were implemented at local school level there were conflicts with other educational priorities such as the emphasis on group instruction for basic numeracy and literacy (BM147) or the need to closely supervise children's use of the internet for fear they should encounter undesirable material (see for example South Eugene High and Tadcaster Grammar). Difficulties are caused by sending mutually contradictory nationally developed policy aspirations into schools. Teachers are confronted with equally compelling exhortations to utilise the power of the internet to internationalise education, but also reminded not to leave students unsupervised in case they encounter inappropriate material (Web Strategy & Support Unit, 2002). They are encouraged to individualise learning using ICT, but commanded to ensure group performance on national tests of literacy and numeracy is assured through whole class instruction (BM143). Other areas of policy conflict reflecting tensions between national and school levels included conservative restrictions in high stakes examinations and inertia attributed to adherence to pre-existing curriculum documents (Plomp, Anderson & Kontogiannopoulou-Polydorides, 1996, pp.11 & 17; OECD, 2001, p.13; Eurydice, 2001, p. 19). Both of these created considerable barriers to ICT adoption in the secondary school area (DM82). The

existence of national curriculum requirements in England led to some highly faithful implementations (MR19), but at the cost of creating barriers to the cross-subject fertilisation ICT facilitates (see Tadcaster Grammar).

5.2.1.6 General trend is towards integration

The communication of policy is an essential part of implementation (NM198; Adamo, 2002, p. iv). There was a considerable lag between the development of policy in the USA and its adoption by schools and districts (Russell, 2000) as well as other examples where linkage to national policy was weak or unacknowledged (as in Theodore Roosevelt Middle, USA). Documents to facilitate this communication were useful, with the importance of exemplification materials stressed in England and the USA (NM182, 202; Thomas & Bitter, 2002). Despite the importance of such communication methods, the analysis of policy documents confirmed previous literature that the general nature of policies for ICT in school education has been predominantly focused upon integration of ICT into current classroom practice (Plomp *et al.*, 1996; Bingham, 2000). This emphasis on supporting the existing curriculum with ICT was particularly strong in the USA (see section 4.2.1.3 on p. 97). Those involved in the development of policy (the expert panel) and others (Knezek, Miyashita & Sakmoto, 1994; Plomp *et al.*, 1996) were critical of the poor current use of ICT in schools, and indicated that much more could be achieved, particularly through the development of new subjects and the use of ICT to cross disciplinary boundaries.

Previous research has been confirmed or extended in the response to Research Questions 1a and 1b which emphasised the current focus on integration and described the way in which national ICT policy comes into conflict with other policies at the point of implementation. The implication is that rapidly changing technology necessitates a frequent re-visiting of policy; and that the considerable lack of policy cohesion in this area is due to this and the multiplicity of rationales behind it. This lack of cohesion calls for the construction of an agreed and future-proofed framework for ICT in education since there is no agreed model at present (NM28).

5.2.2 Research question 2

Research Question 2: How have government inputs such as ICT frameworks, targeted funding and accreditation requirements influenced the use of computers in schools?

5.2.2.1 Types of government input

Curriculum documents provided from national level government had a significant impact on the way ICT was used by students in England and Estonia (BM8/10; EM62), but less so in the USA (DM23). Apart from the policies previously examined, and professional development structures to be looked at in Research question 3, the other major government input was infrastructure resources (UNESCO, 2002). These were often provided through targeted funding, as used by the federal department of education in the USA which promoted ICT equipment support at a level four times the general rate (see the background information for the USA on p. 282), sometimes derived from social equity programs such as Title 1 (DM4). The quality and connectedness of computer workstations, compatibility within an institution, perennial updating of a proportion of the stock and availability of networking were issues (KM6). In some cases computers were of a range of ages, some so venerable that Internet software was not available for them (for example at Tadcaster Grammar). It was found that the disposition of computers within a school was an important consideration for most of the case study schools, having a major effect on what they were able to do with ICT (see p. 106). This study did not examine in detail the extent of internet connections in the case study schools, but there was a range of bandwidth available per capita from the 1Mbit/s for 1000 students at Lyceum Descartes to 64kbits/s for 1436 students at Tadcaster Grammar. The level of infrastructure inputs was deemed by the case study respondents to have a very significant impact on possible curriculum frameworks for ICT (see Couth Eugene High; TE54,). Access to the internet sometimes came into conflict with protective behaviours policies, and student access to inappropriate material on the Internet was a concern (BJ2, KM50). In some cases, local rules about this had disabled the TCP/IP stack (internet connectivity software) on half the school workstations (see South Eugene High case study).

5.2.2.2 The influence of government inputs

There has been a variety of relationships between government inputs and actual ICT use in schools which illustrate the need for defined minimum levels of equipment infrastructure and national policy homogeneity. In Estonia, where a mandatory ICT requirement applies (see Appendix 6.8.6), equipment levels have been too low to permit schools to achieve an integrated approach across the curriculum (TE54). Low infrastructure levels have also been identified as the reason why students spend limited time using school-based ICT (Knezek, Miyashita & Sakamoto, 1994; Plomp *et al.*, 1996; Harrison *et al.*, 2000). These limitations may have led to the minimalist current use of generic office applications deprecated by expert panel members (DM60; NM64). Other studied countries had better infrastructure provision but in some cases have lacked a clear policy approach informing teachers about the purpose of ICT.

Policy cohesion is not easily achieved. In Australia national policies are negotiated through the MCEETYA process, requiring consensus between all States and Territories (Wenn, 2003, p. 19). Where there are no mandatory ICT student curriculum requirements (*e.g.* Australia and USA), adoption has often depended upon individual change agents for whom the reward is intrinsic or through the improvement of class discipline gained by greater motivation (Rogers, 1995, p. 19; HB at Applecross Senior High).

In England there has been a great deal of fidelity between policy requirements and school implementation for the mandatory ICT curriculum (CI 69, 71, 81, 99). However, this has been fragmented between different subjects, and so far lacks a coherent approach (NM34). Selwyn (1999, pp. 81-82) attributed the subsequent lack of success of ICT in UK schools to its policy 'shotgun' imposition through purely technology resource supply or functional terms instead of alignment with educational objectives. Fullan (1992, p. 29) concurred, emphasising the need for policy to clarify the meaning of change for those involved, culminating in new beliefs and understanding. Both authors emphasise the difficulty of achieving these new attitudes when policy is predominantly concerned with the supply of technology resources. Selwyn (1999, p. 85) also attributes policy failure to "the isomorphic structure of the

school ... still rooted in industrial society”. This kind of structure where all the students in a class undertake similar activities at the same time does not fit an innovation ideally suited to individualisation and timetabling flexibility. Integration of ICT into traditionally structured schools is therefore difficult. This mismatch between adoption context and proposed innovation inhibits a transformative alternative or new business model.

The choice of integrative or transformative approaches may be a matter of timescale. Selwyn counselled policy makers to address “the quality, not the quantity, of the integration of computers into the school curriculum” (p. 87). Some people believe such an integrative emphasis will eventually transform the curriculum (BM 75) and “help solve inter-disciplinary problems” (DM 81). Other members of the expert panel asserted this transformation was already evident (KB 195). The implication is that successful adoption will depend upon all the critical success factors previously identified for ICT in education, as well as a policy view which embraces a transformative rather than an integrative perspective.

5.2.2.3 The tendency for collapse to generic office applications

The expert panel believed that one consequence of the policy focus on integration had been the contraction of ICT use in schools to generic office software (KB107; NM132; MR123). There was a considerable shortfall in expectations, as found in a doctoral study in the USA, with students using some word processing or rewarded for good behaviour with computer games (DM60). Because they had more flexible timetabling and fewer accountability requirements, primary schools were more able to exploit ICT (TE128). This was in contradiction to the finding in the literature that ICT can increase learner autonomy where this is a pre-existing part of classroom practice (IAEEA, 1999).

5.2.2.4 Schools’ own initiatives

Individual schools were introducing ways of using ICT in new ways unsupported by policy guidance. These approaches included greater authenticity in teaching materials

through the use of contemporary images in student project work (WL at Applecross Senior High), the incorporation of self-paced interactive tutorials (HB at Applecross Senior High and KF at Theodore Roosevelt Middle), and student collaboration in international problem solving activities (DM2 at Theodore Roosevelt Middle, USA). These new approaches agreed with the finding from the literature that ICT can increase student-directed learning (Woodrow, 1999). Other school-initiated exploratory activities included the use of wireless networking for internal mobility (at Applecross Senior High), and for inter-campus connectivity (at Winthrop Primary and Lyceum Descartes). School-based development to support administrative functions and enhance links with the community included the third-party portal proposed at South Eugene High. Individual school-based change agents (as VT in Pärnu Nüdupargi Gümnaasium) showed signs of a transformative approach to education in that very traditional context. However, teachers in the case study schools reported little incentive to pursue such transformative uses of digital materials other than the intrinsic rewards of greater student engagement or easier classroom management (*e.g.* HB from Applecross Senior High, Australia). These initiatives were proceeding without policy mandates or guidance, and illustrated the way in which the rapid rate of change was facilitating such experimental projects. Major changes were anticipated at Applecross Senior High, as the school contemplated the form of its next consolidated digital repository for curriculum and library materials in a user-aware way. In these cases the use of ICT was causing a re-think about the way information flows within the organisation could take place.

5.2.2.5 The growth of home computers

Student home computers were emerging as important tools for off-site learning and access to school resources out of hours (see Applecross Senior High; KM8, 50), thus extending the Australian literature (Meredyth *et al.*, 1999b) to other countries (see Lyceum Descartes case study). School-level policy and implementation mostly ignored this higher availability of ICT in student homes (see Table 14 in section 4.4.1), with none of the case study schools having a developed local policy in this area, except floppy disks from home were allowed at Applecross Senior High (KM50). Despite this lack of policy, schools were pursuing activities which facilitated computer use at home, with most work word-processed: “Even though it is not stated,

virtually everything is done on computer” (KM60). Reasons given by teachers for not incorporating home ICT into their practice included equipment incompatibilities and the perceived inequities of student access to computers and the internet at home (SS20; BJ34; SP58). As the digital divide has rapidly diminished for families with children (Australian Bureau of Statistics, 2000d), the equity argument has become increasingly untenable (CI65), but teachers in the case study schools have yet to be convinced to incorporate home computers into school education, citing the relatively high cost of a new computer (CI63), the difficulty of accessing one in a public setting, and incompatibilities of equipment as reasons to continue to ignore them outside school (for instance at Applecross Senior High).

5.2.2.6 The growth of CyberSchools

Several examples were found where transformation was taking place on a broader scale, such as virtual schooling in the pan-European Virtual School (European Schoolnet, 2000), the growth of virtual schools in the USA (Russell, 2003) and integration of home and school-based learning environments (Department for Education Training and Employment, SA, 2000; Foreshaw, 2000; Mitchell, 2000; Clark, 2001). The CyberSchool in Oregon (described in the case study on South Eugene High) provided a greater range of curriculum opportunities for students without having to leave their neighbourhood school (Layton, 1999). Such ICT-mediated communication deriving from online learning materials has benefits for students by allowing them to access a wider range of courses than would be possible with limited staff numbers and timetabling viability restrictions within a single institution. These government inputs have broadened to include electronically mediated supports for teachers through agencies such as the National Grid for Learning in England (MR185; NM182) and the ‘Free’ web-site in the USA (DM9).

The answer to Research Question 2 has revealed there is little agreement locally which substantiates the pedagogical rationale. Many schools are implementing government supported ICT programs with difficulty. Equipment sufficiency, conflict with other priorities and lack of extrinsic rewards for teachers were all found to have a bearing on the way in which computers were used in schools. In a growing number of

cases there are non-school based government programs to expand ICT in k-12 education.

5.2.3 Research question 3

Research Question 3: What teacher professional development policies and procedures were evident in the countries studied?

5.2.3.1 Pre-service and in-service ICT operational skills focus on integration

Policies for teacher ICT professional development were generally focused on operational skills, in fact, if not in principle. This level of expectation was explicit in Estonia, where the International Computer Driving Licence (Australian Computer Society, 2002b; see Estonian ICT requirements for teachers in Appendix 6.8.5) was the national training standard (TE136, 138). Much of the national NETS framework in the USA was based upon generic office applications, although classroom practice was expected to go beyond such tools. Policy in England had also provided a national training scheme targeted at ICT integration into teaching practice through a large lottery-funded professional development project which presumed and required teachers to have basic operational ICT skills as a foundation (BM38). This program was providing differentiated training to every in-service teacher to the same standard as required for new teacher education graduates. However, a sample benchmark test for the latter was predominantly concerned with mastery of generic office applications (Teacher Training Agency, 2002), putting it at a similar level to the Estonian objectives. It was generally the case that standards for in-service teachers were very similar to those for pre-service teachers (DM33; MR191, 195; KB11) and were mainly mandatory (see Table 8 in section 4.2.1.1). The focus on the mastery of generic office applications appeared to be linked to the policy focus on integration. This could be seen as a confidence-establishing preliminary state, but since micro-computers have been in schools for nearly 25 years, perhaps one that has been tried and found unfruitful.

5.2.3.2 'Ownership' as an element of teacher ICT professional development

The literature had identified ownership and relative advantage as the most significant factors for innovation adoption (Clayton, 1993; Parker & Sarvary, 1994). Ownership in the sense of innovation arising from within an organization was interpreted and implemented through personal equipment schemes. There was evidence of computer ownership schemes for teachers as an adjunct to professional development in some states of Australia and throughout England (National Grid for Learning, 2002; OFSTED, 2002, p. 3; State of Victoria (Department of Education & Training), 2002; Becta, 2003) and this was confirmed in case study schools (see Applecross Senior High and Winthrop Primary, Australia). However, the expert panel members considered that there was a considerable lag between technological advancement, student uptake of ICT skills, and teacher readiness to utilise these (EM1).

5.2.3.3 The amount of professional development required

The amount of time teachers need to become familiar with ICT in the literature was estimated at nine hours per year (Smerdon et al. 2000) and should take about 30 percent of the ICT budget (Byrom, 1997). This was confirmed in the study where 40-50 hours of initial training were expected (see p. 304 in section 6.10.6), and the expert panel deemed 12 hours of professional development required per year to maintain currency in the face of continuous software upgrades, taking 15-30 percent of state ICT funds allocated to ICT (DM84). The aging of the profession and difficulties with recruitment (see p. 60 in section 2.6.1.2) makes it difficult to provide the time teachers need for professional development in ICT. These additional factors are accentuated by the constant revision of generic office software used as the basis of much teaching and compounded by the frequent emergence of additional innovative equipment. To extend teacher knowledge to subject-specific innovations requires yet more teacher time. Training in the application of subject-specific software, which has a range of non-standardised controls, makes the whole area highly problematic. This is a very different situation to most business applications of ICT which expect the user to operate one program for considerable periods. By contrast, teachers and students normally expect to cover a wide range of curriculum areas and content over a 12 week period. One emerging solution is to package access to a catalogue of 'learning

objects' accessible through a standard web-browser, which minimises the training required for individual teachers (The Le@rning Federation, 2001; Learning and Teaching Scotland, 2003).

5.2.3.4 Assessing the effectiveness of teacher ICT professional development

Several ways of assessing the effectiveness of ICT professional development have been proposed. One metric in the previous research observes actual teacher use of ICT in classrooms (Bender, 2000). The expert panel suggested the criterion for successful ICT professional development is the subsequent quality of teacher decision-making (KB137), and that it should be done using authentic situations (TE148). Another way to evaluate this is to look at subsequent curriculum changes (EM89). This method opens up a whole raft of important issues because it suggests the traditional curriculum cannot be used as the yardstick of successful teaching with ICT. There are several accepted ways to assess student learning outcomes in respect of ICT use, and these are now examined.

5.2.3.5 Lack of alignment between teacher and student ICT standards

Student ICT learning outcomes can be assessed using the standards produced as part of national policies and examined in the Results section of this thesis. In the ICT area, teachers are typically being trained in tandem with their students: not a normal state of affairs since teachers are in most other respects fully trained at the start of their appointments. Consequently, skills standards for teachers and students are being produced simultaneously in each of the sample countries. In the centralised system of England, these sets of standards were the responsibility of different government departments (KB11), and it was asserted that the standards were out of alignment with each other (KB163). This extended previous literature which had been silent on the issue of alignment. The alignment issues in the findings were particularly identified in respect of the difference between what students were expected to learn about ICT and what teachers were expected to teach. This discrepancy due to lack of inter-departmental liaison did not apply in the USA since the ISTE organisation was the proponent of both student and teacher standards (International Society for Technology in Education, 1996 & 1998); but nonetheless teacher ICT skills appeared to have been

considered independently of student ICT skills and many teachers cannot themselves achieve the student standards (DM17-18). This divergence at the policy level is then left to resolution at the school level with a great diversity of consequent approaches. It also explains the crucial nature of individual change agents, most of whom are teachers (see for example VT in Pärnu Nüdupargi Gümnaasium, Estonia). The question of alignment also extended to the relationship between teacher professional development and strategic priorities (Downes *et al.*, 2002). How alignment might be achieved is beyond the bounds of this thesis, but the issue has been identified and explored here.

5.2.3.6 Assessing ICT by student learning outcomes

Another way to assess student learning is to use non-ICT specific curriculum frameworks as in the literature on ICT effectiveness which uses meta-studies to compare learning outcomes with, and without, ICT (Sinko & Lehtinen, 1999). Perhaps the most important point to make here is that ICT appears to be flexible enough to support these existing curriculum frameworks about as well as other innovations (Parr, 2000). ICT also appears from the descriptive research (McDougall, 2001) to be able to foster new ways of learning about new topics, but there is insufficient literature exploring this idea (OECD, 2001; Venezky & Davis, 2002, p. 35). Therefore the pedagogical rationale examined in Research Question 1 stands upon a base which assumes a curriculum which has not changed to accommodate new learnings and new ways of learning. Furthermore, there are implicit resourcing issues here because the cost of providing and maintaining the currency of ICT infrastructure in schools appears to be a major factor inhibiting good use (OECD, 2001, pp. 16 & 93; Eurydice, 2001, pp. vii & 17). This would appear to be supported by the discrepancy between home and school equipment levels (see Table 14 in section 4.4.1).

The response to Research Question 3 is therefore one which identifies existing ICT professional development as focused on operational skills for integration, with some examples stimulating teacher computer ownership. Relative advantage of ICT is about as good as other innovation in education, but there is a lack of alignment between

teacher ICT professional development, national strategic purposes and ICT standards for students.

5.2.4 Research question 4

Research Question 4: In the light of the preceding research questions, is it possible to describe the use of ICT in schools within a particular framework which indicates future directions?

5.2.4.1 Findings from the previous research questions

The answers to the previous research questions have shown that there is a need for an agreed framework for ICT in school education, prompted by the growth of home access to computers and of cyberschools, the lack of policy cohesion in the area and the questionable validity of using pre-existing curriculum outcomes to assess student learning acquired through ICT. Such a framework would have to address the difficult policy areas of home-school ICT relationships and currently low standards of ICT use. Whereas national and local policies focus on integration, schools are comparative computer deserts compared to students' homes, despite considerable government ICT funding of £2.7 billion per annum in England for example (Department for Education and Skills, 2002). This disparity in equipment was rarely recognised in school policies or by teachers. In addition, some experts were critical of the relatively low expectations of ICT in schools, comparing current activities such as word processing with the capacities of equipment to predict weather for large geographical areas (DM82). Once again, this is despite considerable government resources being put into teacher professional development (New Opportunities Fund, 2002; BM27).

5.2.4.2 Possible ways to resolve these difficulties

The literature review established that rapid changes in the underlying technology underpin these challenges for decision-makers in the public policy arena (Moore, 1997; Carrick, 2002). Theoretical responses vary from the rationalist liberal capitalist approach for strictly hierarchical governments, through the 'satisficing' art of

compromise (Simon, 1993) to the muddling through incrementalism of Lindblom (1959). Whereas an incrementalist view would make small changes in policy, the study has identified major differences between leading and laggard institutions. There is evidence that current approaches to policy are not sufficient (Papert, 1993; Holmes, Savage & Tangney, 2000, para. 3.1; OECD, 2001, p. 112) because ICT is leading to fundamental changes in curriculum. Therefore major policy changes may be required to meet the challenges identified above. Previous studies had suggested that undesirable consequences of innovations cannot be minimised (Rogers, 1995, p. 11-1). This aspect has been little studied in the area of ICT in school education and existing models of stages of development have largely ignored it (see for example Kraver, 1997). However, the story of ICT in education is one of the struggles of teachers to do just that. This study has described some of the efforts that individual teachers have contributed to their students' successful and innovative use of ICT.

5.2.4.3 The possibility of building a new framework

The development of a particular framework for ICT in school education needs to be grounded in the experiences of teachers and policy makers to ensure a more faithful adherence to practice in the description of current practice and expectations for the future. Previous frameworks explored in the literature review have been developed largely without such a link to an international data set. The literature set the parameters for any future framework: it should apply to a range of audiences (Dwyer, Ringstaff & Sandholtz, 1991; Dwyer 1994) and be based upon the capacities of existing ICT equipment (Kraver, 1997; Valdez *et al.*, 2000). It could also link to national 'knowledge economy' strategies (Caldwell & Spinks, 1998). The study found there were expectations and examples of transformation of school education as described by Heppell (1993).

This transformative view is compatible with the work of Perkins, Schwartz, West and Wiske (1995) who, in reference to ICT in mathematics teaching, stated that "changes in degree, helpful though they might be, simply are not enough" (p. 89). They examined uses of technology that "foster changes in the nature of teaching and learning, not uses that only improve the efficiency of what was done in the past". It was found that although policy was generally focused at the integrative stage, policy-

makers at national and school level were expecting and implementing new uses of ICT which were changing the educational process. An important element of this was the incorporation of student home computers as a learning tool. Therefore it is reasonable to conclude that a particular framework can be devised which may indicate transformative future directions, and which also fits both the constraints learned from previous models and the data from this investigation.

5.2.4.4 Examination of three propositions for ICT in education

In the derivation of a model accurately and usefully describing the stages of development of ICT in school education, three competing propositions were suggested from previous research and the results of this study. The determination of which of these propositions is supported by the evidence depends upon the plausibility of interpretations for each, and the empirically discovered relationships between interpretations and theories (Popper, 1957, p.131; Smith, 1975, pp. 275-276).

The ‘bubble burst’ proposition: that ICT in school education would increase and then decline into very limited use, as other technologies have done in the past (Costello, 2002).

The integrative proposition: that ICT in school education would increase and then plateau at a particular level of use. This proposition could be developed further to determine the kinds of use, whether as a separate subject or spread through other curriculum areas (Department of Education, Training and Youth Affairs, 2000, p. 11)

The transformative proposition: that ICT in school education would continue to increase over the foreseeable future and transform both existing curriculum subjects and the nature of the teaching and learning process (Nichol & Watson, 2003, p. 133).

The bubble-burst proposition suggests that ICT in school education will follow the path taken by information technology stocks and shares in the year 2000, when the Nasdaq computers index fell by over 70% of its peak in a period of twelve months. It is unlikely in the prevailing policy climate that this will happen to ICT in schools education, and in fact demand for ICT goods and services climbed through the ‘tech-wreck’ period (Matsuo, 2003). It would be quite unusual for the education sector to become independent of a class of innovations affecting almost every other area of

society, especially homes (Di Gregorio & de Montis, 2002; OECD, 2002b). This proposition is therefore not accepted on the evidence available at present.

The integrative proposition reflects the current policy thrust (Plomp *et al.*, 1996; Bingham, 2000). As shown in the discussion of Research Question 1a and 1b, this proposition stems from a focus on the economic rationales and is synonymous with a focus on generic office applications and teacher professional development aimed at operational skills. The sustainability of this integrative state therefore depends upon continued satisfaction of its resourcing requirements and lasting policy commitment to the supporting rationale.

The transformative proposition has been considered in the light of evolutionary and revolutionary transitions (Nichols & Watson, 2003, p. 133). There is policy pressure for such an approach from the members of the expert panel in this study, who regarded current use of ICT as “mundane” (see for example DM20, DM46). Additional support derives from the case studies, for example the CyberSchool discussed at South Eugene High, the Miksike collaborative web-site at Descartes Lyceum and the use of interactive mathematics web-sites at Applecross Senior High, each of which demonstrates the use of ICT to enhance off-campus learning. The transformative proposition suggests that standardised tests using tradition measures may be inappropriate when ICT is a significant feature of learning (Fouts, 2000, p. 27).

Both the integrative and transformative propositions can be accepted on the basis of existing evidence. The consequence is to determine whether they are alternatives existing side by side, or whether they are ordered with one proceeding the other for a given school or system. A grounded theory approach was used to develop a model to explain the way in which these two propositions could interact.

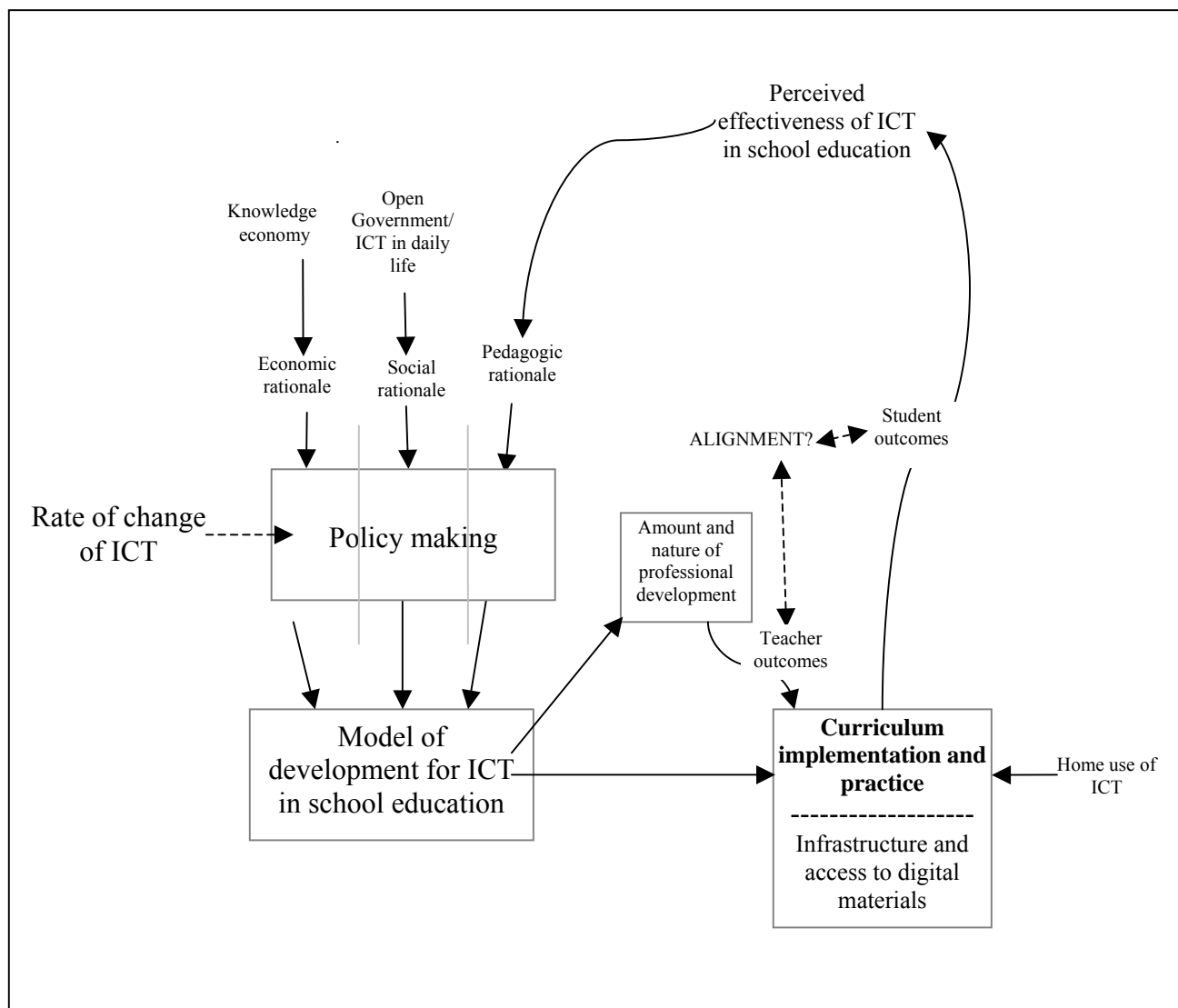
5.2.4.5 Connecting the categories with a logic diagram

The researcher became theoretically sensitive through the extensive literature review, professional work in the field, data collection and analysis. Therefore it was possible to categorise the material from the study, assign properties and dimension them.

These analyses are presented in Appendix 6.13. Open coding (Corbin & Strauss, 1990, p. 12) was carried out until theoretical saturation of the categories was achieved (Glaser & Strauss, 1967). The categories were connected with their contexts, strategies and consequences, through axial coding. The core category of ‘model of development for ICT in school education’ was chosen because of its centrality between ‘policy making’ and ‘implementation and practice’.

In a grounded theory approach, the logic diagram brings together the findings of the study and the literature. It shows the cycle of policy generation, implementation and evaluation (Jenkins, 1978, p. 17; Bridgeman and Davis, 1998, p. 24) as found in the area of ICT in school education. Policy generation has been shown to respond to three rationales, the economic flowing from ideas of the ‘knowledge economy’, the social and the pedagogic. The pedagogical rationale is dependent on operationalisations of ICT effectiveness (McDougall, 2001). Policy is mediated through an implicit or explicit model of stages of development to drive implementation through the curriculum. This implementation and practice is dependent upon equipment, connectivity and digital materials such as application software, databases and online teaching resources. Student learning outcomes are the result of this implementation and practice, and there are difficulties with alignment of these (actual or desired) and teacher professional development. The outcomes are affected by student home access to ICT, but this is rarely a component of policy generation at national or local school level. A logic diagram was constructed which illustrates the connections between the conceptual categories found in the study (see Figure 6).

Figure 6: Logic diagram of relationships between concepts



5.2.4.6 Development of the proposed model

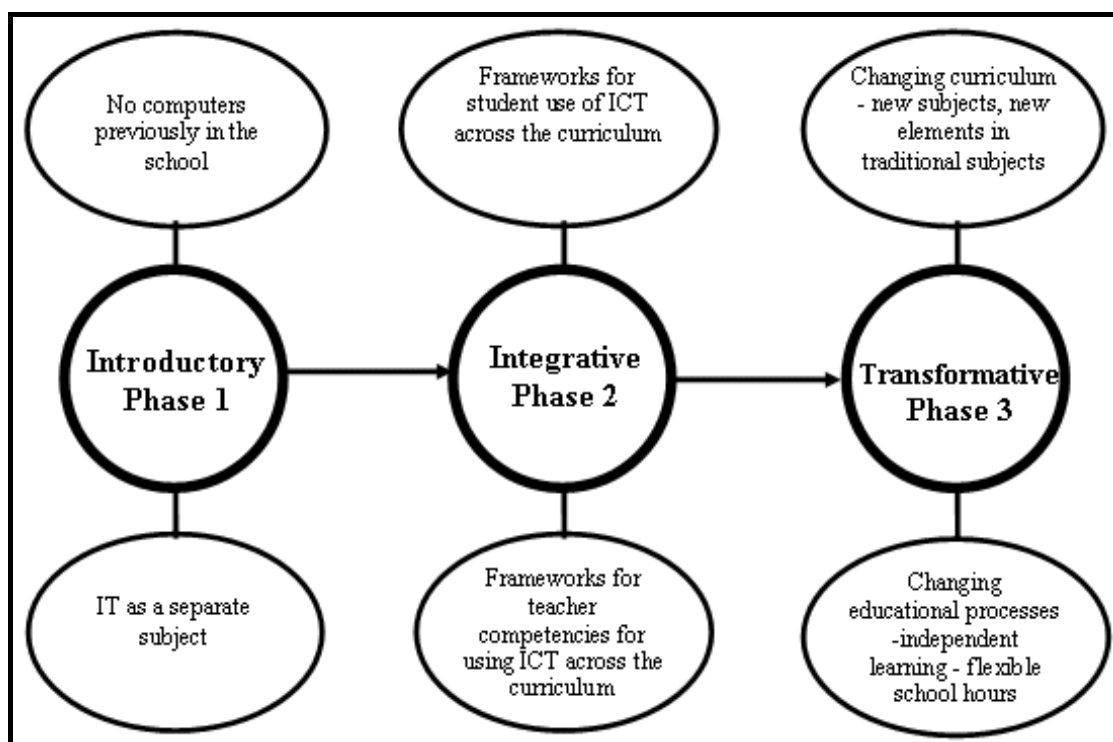
The study methodology made use of multiple methods and collected data from multiple sites and persons to eliminate interaction effects found in other studies where sampling has been affected by treatment bias (Good, 1972, p. 373). Both the literature review and the data indicated that current practice is relatively poorly regarded, and has much potential for improvement. Some individuals and some systemic initiatives have moved on from the integrative phase. Therefore it is necessary to extrapolate from the observed trends and see what these leaders are doing as they try out new

ways of working without policy guidance. The consequences of a transformative stage are being explored in local situations as schools experiment with the possibilities of the new technologies.

The proposed model had to match some very specific requirements which were identified in the literature review (see section 2.5.1 on p. 57). For the model to be useful, it had to be sufficiently general to accurately describe the situation well, yet be simple enough to avoid over-complexity. This meant the model had to describe a minimum number of developmental stages to match the evidence, yet not include Heppell's superfluous stages. The other requirements were derived from the open coding analysis, and included application, generalisability, validation, assumptions and alignment. The property of application required the model to cover as many school sectors and age groups as possible. The model was validated against a diverse range of school situations in the case studies, which had been drawn from geographically diverse areas. Alignment could be demonstrated by using the model as a starting point for development of future teacher ICT professional development and student learning outcomes.

From the data, the open coding analysis, logic diagram and the literature, a proposed model was constructed to describe stages of development for ICT in school education. This outlines three stages of development; the introductory, the integrative and the transformative (see Figure 7):

Figure 7: A general model for the development of ICT policies in schools



5.2.4.7 Characteristics of the model

The introductory Phase 1 corresponds to the period where the school, system or participant meets computers in education as a subject to be studied. This would cover contexts where ICT was an examination subject or was only studied in terms of operational skills. The integrative Phase 2 describes contexts where ICT is incorporated into the teaching of other subjects, and is included in teacher planning. However, there is little or no change to the curriculum or the learning outcomes expected of students. The transformative Phase 3 makes no assumptions about the place or timing of learning, and includes contexts where topics studied include those that are not possible without ICT.

This model was further developed to establish levels of particular attributes for phase transitions by extracting from the data details of student use of ICT, ICT professional development for teachers, school implementation (including frameworks for student

ICT learning outcomes) and government intentions/philosophical approaches. The levels of similarity and the overlaps between practices in the different case study countries contributed evidence for the three-phase model. Even though the political pressures and the educational administration arguments used to justify ICT developments in schools in each country visited were different, there was consensus about the overall direction in which these developments would take students.

These issues and observations from the case studies and policy reviews were incorporated into the consolidated table (Table 34) which gives values for transition from each Phase to the next. The critical values derived for the development of the model relating to student use of ICT reflected the degree to which home access to computer and the Internet were available. Since younger students generally had less access than older ones, a medium value on age of 11 years was set in the comparative table of Phase transition indicators in the Table. As the Phases overlap, the headings indicate the transition using a slanting line. Attributes within a Phase also vary, and this is shown by separate columns for the starting and consolidated values divided by a dotted line. Thus the initial school and home workstations for the integrative Phase 2 were 486 PCs (typically) but through a process of maturation and technical development, multi-media computers were more representative by the end of the Phase.

The proposed three-phase, two-level model for the stages of development of ICT in school education resolves difficulties with competing propositions in the area and is supported by policy documents, an expert panel and case study observations. It also overcomes the problems of models in the literature by using a multi-site, multi-method study with case study and literature analysis techniques. This current study is the only major research which has been conducted with a focus on the global transition of education from an industrial group-instruction stage to a post-industrial ICT based stage. While some locally-based planning guidance documents gave a series of stages through which a school might pass, none of these was based on country visits or an analysis of what was actually happening in schools around the world.

The new model requires interpretation for application to policy-making at national, regional and school levels. A central feature of Phase 3 in the model (see p. 139) is transformation in the way in which school education is delivered, with an expected increase in differentiation through the use of ICT-mediated flexible delivery for ‘independent learning’. More decentralised education systems were more conducive to this axial principle (Bell, 1973; Jones 1980, p.112). For instance, the centralised education system of Estonia had not considered ‘independent learning’ as part of the ICT curriculum framework, and was inhibited from broad implementation of transformative Phase 3 by low infrastructure levels. However, some ICT-based remote teaching was being done on purely pragmatic grounds to deliver advanced courses to students in remote locations. England also represented a centralised system which had adopted some ICT-mediated independent learning where deemed appropriate. Infrastructure was good, and there were a few examples of online learning. In the devolved context of the USA infrastructure was excellent, yet independent learning had been excised from the national ICT framework for students but was clearly evident in the case studies. Finally, the highly devolved Australian context had no national ICT curriculum framework, infrastructure was excellent, and there were many examples of ICT-mediated independent learning emerging.

Much evidence of the transformative Phase 3 can be seen in tertiary education, where 70 percent of USA institutions taught subjects by the Internet and about one in three had whole degrees taught that way (Lawnham, 2000). Examples of completely ‘virtual universities’ include international consortia such as Western Governors’ University (Western Governors’ University, 2000), Universitas 21 (University of Nottingham, 1999), Scottish Knowledge, NextEd (Richardson, 2000) and Boxmind (O’Reilly and Hellen, 2000). Competing with these commercial ventures are free, fully accredited university courses (SAATech, 2000; Vest, 2001) and open source online course management systems from a variety of reputable sources (OKI, 2002; Narmontas, 2003).

A final demonstration of the approaches being taken in transformative Phase 3 has been the response of textbook publishers. Some conventional text book publishers are now providing extension CD-ROMS and linking their normal products to

complementary web-sites. The latter extend the content, provide updates and amendments, test understanding through quizzes and allow the publisher to advertise new material (Roblyer & Edwards, 2000, p. 251). Wiley is an example of a publisher that provides on-line courseware to teachers:

Aside from receiving robust, already developed e-packs, adopters of selected Wiley texts receive a pre-paid site license to use WebCT, 24-hour technical support, and password access to the Wiley WebCT Course [partnering the title] (Wiley, 2000)

These examples were no longer rare at the time of writing and represented a significant shift from printed educational materials to providing them electronically.

Providing advice for Australia in the field of ICT in school education was one of the main aims of the study (p. 14). This is done by applying the model to two states in the following section.

5.2.4.8 Application of the model

School curricula in Australia have been the responsibility of the individual states and territories forming the Commonwealth (Commonwealth of Australia, 1991). Common goals were agreed in 1989 (Ministerial Council on Education, Employment, Training and Youth Affairs, 1989) and revised in April 1999, establishing eight key learning areas. The key learning area of Technology incorporated the idea of ‘data’ as a raw material, giving students the opportunity to create information products. The curriculum developers and the writer of this study took the analogy that data + processing = information (Australian Education Council, 1994). This approach was at the level of the introductory Phase 1 of the model, since it facilitated the study of ICT for its own sake. Bigum *et al.*, (1997) subsequently commented that development had almost stalled, not because of difficulties in accessing sufficient and powerful equipment, but because teachers in the main were unconvinced that deployment of ICT held educational value for students. While maintaining the equipment, and providing a continuous stream of training was proving problematic, teacher cynicism still formed a significant barrier to increased utilisation. Most pupil uses were unauthentic and for lower-order thinking skills, with most applications involving word-processing, rote learning, and simple information reproduction.

Development was revitalised when education and training were included in the Australian strategic framework for the information economy (National Office for the Information Economy, 2000). Federal action for schools was illuminated by a research project which strongly recommended the promotion of ICT integration into all teaching and learning (LifeLong Learning Associates, 1999), articulated in the school sector plan as “improving student outcomes through the effective use of information and communication technologies in teaching and learning” (DETYA, 2000b, p. 3). Running in parallel with these over-arching strategies from the Commonwealth government, state-based activity relating to ICT in schools was remarkably diverse. A summary article outlined the main characteristics of the many programs in progress at that time (Lelong & Summers, 1998). Additional state summaries were available from the Education Network, Australia (EdNA, 2000) website.

The proposed model is compared against two sample states, chosen for the differences between them, their representative nature, and the researcher’s familiarity with them.

5.2.4.8.1 *Queensland*

Queensland had a ‘Schooling 2001’ project (Lelong & Summers, 1998) which had five components, all designed to improve student learning outcomes through integrating computers in the curriculum. The five components were to provide technology infrastructure, develop staff IT skills, provide quality software, evaluate the effects of ICT on student learning outcomes and a marketing strategy to promote awareness of worldwide information resources. Among these strategies were some very specific teacher learning technologies competencies (Education Queensland, 1998) which were to be included in enterprise bargaining negotiations, with the aim of progressively getting accreditation for all teachers by the end of 2001. They built upon the *Guidelines for the use of computers in learning* (Department of Education, Queensland, 1995) which identified the main goals for students using computers. Students were expected to use computers for a range of purposes; namely to develop operational skills, develop and understanding of the role of computers in society,

critically interpret and evaluate computer-mediated information, develop skills in information management and develop appropriate attitudes to the use of computers.

Queensland was revising school curricula through ‘the New Basics’ (Education Queensland, 2000). ICT was subsumed into the learning area of multiliteracies and communications, the others being life pathways, active citizenship and environments/technologies (p.43). The opportunity for transformation was expressed thus: “new communications change the way we use old media, enhancing and augmenting them” (p. 50). However, this has to be done in the context of preventing curriculum overcrowding and preserving traditionally important skills such as handwriting.

New Basics has an emphasis on locally produced operationalisation. It includes a panel of ‘Rich Tasks’ to demonstrate student competency and acknowledges a need to raise retention rates into Year 12 by some 20 percent. With such imperatives dominating the development of this new curriculum model, the issue of the way in which ICT has the potential to really modify the way schools work appears to have been lost. Certainly, there was a commitment to a Virtual School, but this seemed to be no more than a face-lift for existing distance education services. Therefore, although the strategy paper acknowledges that students will need new skills to understand and work within a culture permeated with new information technologies, the result is only at the level of the integrative Phase 2 of the model while holding out some opportunity for elements of transformative Phase 3 to emerge at a local level.

5.2.4.8.2 *Tasmania*

Tasmania has a history of support for ICT in school education dating back to 1972, notably through the Elizabeth Computer Centre (Bowes, 2001, p. 38). More recently, general ICT initiatives have been guided by a strategy paper which adapted the ACOT stages for students to define a progression through accessing, extending, transforming and sharing information (Freestone, 1997). Additional investment to overcome barriers to adoption has provided equipment, networking, maintenance, professional development, and the ‘Discover’ web-site (EdNA, 2000). The Discover site has been

a key component in strategy, hosting a large range of OPEN-IT on-line learning materials (see <http://www.discover.tased.edu.au/netlearn/coursest.htm>), originally devised to support learning where specialist teaching was not available, but more recently hosting materials targeted at the bulk of grade 7/8 students in schools (Annells, 2000). This move from learning on the periphery to learning in the core marked a significant change, reinforced by ICT skills requirements in teachers' job descriptions (Deputy Secretary (Corporate Services), 2000). Employment patterns were changing as school-based teachers and students participated in the state-wide 'Discover online campus', from which online courses were run without the need for co-location. This required special attention to school funding, which had previously been site-specific. Employer professional development still concentrated on operational skills, with only one of five modules for in-service teachers focusing on 'integrating ICT into teaching and learning' (Sigrist, 2000). Encouragement for ICT from the teaching profession has been quite explicit. The local branch of the Australian Education Union adopted a policy in 1999 that stated "students should be able to spend up to 20% of instructional time using modern computers" (Australian Education Union, 1999, p.1), three times that found in a local study (Fluck, 2000).

It is evident that many schools have used ICT in novel ways. Examples include a 'travel-buddy' project used to connect a Tasmanian school with three schools in Argentina (Duggan, 2000), benefiting from the commonality of the school year for southern hemisphere countries. A post-compulsory college (student ages 16-18) reported 20 percent of its teaching load was in the online courses, with half the 162 staff involved (Andrews, 2001). Flexible learning has contributed to at least one school adopting a nine day fortnight (Wade, 2002) and improvements for students who find school a challenge (Esk Express, 2002). A framework for integrating ICT into school education was adopted by many schools (Computer Education Discussion Group, 1996; Byron, 1997; Fluck, 1998). These activities point towards the integrative Phase 2 of the model with indications of strong preparation for the transformative Phase 3.

A summary of the progress of the other Australian states towards each of the phases of the model is given in Table 35. This study now concludes with recommendations for various elements of the education profession and for future research.

5.3 Recommendations

Recommendations from this study fall into two main groups: those for use by particular groups in the field of school education (E1 to E3) and those for future research (R1 to R4). Although particular audiences are specified for each of the first group, there are examples where concerted action is required by other actors for the recommendation to have effect. In particular, the issue of alignment between policy areas requires cooperation on a wider scale.

5.3.1 Recommendation for the teaching profession

E1: ICT professional development for teachers should be considerably extended, aligned with student learning outcomes, and encompass a wider range of ICT applications relevant to their area of teaching specialisation.

Data from Australia show that some accreditation authorities are requiring teachers to be able to use ICT and understand its role in educational practice (Board of Teacher Registration, Queensland, 1999, 6.11 & 6.29; Australian Council of Deans, 1998; Education Department of Western Australia, 1998, p. 6). Evidence from international studies shows the latter requirement is often an optional part of teacher training in Australia (Department of Education, Training and Youth Affairs, 1999a, 1999b). This may need to become a mandatory requirement, developed in line with guidelines established by the peak professional association (Williams & Price, 2000, pp. 6-41) and a recent investigation into current practice (Downes, Fluck, Gibbons, Leonard, Matthews, Oliver, Vickers and Williams, 2002). Competency standards for this have been explored (UWS, ACSA, ACCE & TEFA, 2002) but need to be aligned for those for students (see recommendation E3).

The strategy of facilitating teacher computer ownership appears to be a cost-effective way to maximise training opportunities. Teachers need to examine the evidence of ICT efficacy to assess 'relative advantage' (Clayton, 1993; Parker & Sarvary, 1994;

Rogers, 1995), by visiting local centres of excellence, and having the time to become confident in their own skills. Many need to reflect on the equity implications of ignoring the full extent of home computer and Internet access by students. As the Education Department of Western Australia (1998, p. 6) put it: “Teachers will include the roles of facilitator and coach, while students will add the roles of mentor and teacher”. Although the Australian Teaching Council has disbanded (Williams, O’Donnell & Sinclair, 1997), this recommendation might be best addressed by professional associations working in tandem with systemic agencies.

5.3.2 Recommendation for teacher training accreditation agencies

E2. Systemic accreditation schemes for pre-service teacher training courses should permit a limited proportion of practicum or school experience to be completed in virtual classroom settings.

The study identified the growth of virtual schooling and the transition of this delivery mode from the periphery to the mainstream (Annells, 2000; Feeney, Feeney, Norton, Simons, Wyatt, & Zappala, 2002, p. 41). Given the growing importance of this mode of teaching, it is appropriate to suggest that pre-service educators are given the opportunity to generate online course material and supervise students who are using this in their learning. Most teacher education courses include mandatory professional experience components, but regulatory processes rarely foster the acceptance of virtual teaching and timetabling pressures often exclude a virtual practicum alternative. As an example, pre-service teachers are required to undertake “not less than 100 days of professional experience, with a minimum of 80 days’ experience in schools and other appropriate educational settings” (Board of Teacher Registration Queensland, 1999, p. 17). Exactly 80 days of professional experience were included in the calendar of such an approved course (James Cook University, 2000). This recommendation to permit some limited professional experience in a virtual practicum endorses that of Downes *et al.* (2001, p. 80).

5.3.3 Recommendation for national decision makers in Australia

E3: In relation to curriculum, national authorities in Australia such as MCEETYA should consider existing ICT frameworks and determine whether adopting such a framework nationally would promote policy cohesion and alignment.

Previous work has been done in Australia on frameworks for student use of ICT (Australian Council for Computers in Education and the Australian Computer Society, 1995; ACT Department of Education & Training and Children's, Youth & Family Services Bureau, 1996; ACT, 1997). However, these have not been used to generally focus and align policies for professional development and student learning outcomes in the way indicated as necessary by this study. There is evidence from the USA that federally adopted standards can be disseminated and implemented through the use of policy instruments such as targeted or tied funding like Title 1 or the E-rate (DM4). This recommendation endorses the suggestion that "a consistent approach within the school system ... must cover how technology is applied within schools to aid the learning process" (Hogg, 2002). Such a framework should be communicated to teachers by using sector-specific exemplification materials and should be aligned with ICT standards for teachers (NM interview; O'Donnell, 1996, pp. 121-126). Such a framework would need to include the 'independent learning' mode (Wood, 1998; Fitzgerald & Fitzgerald, 2002). Evidence from the case studies showed schools were adopting these techniques to broaden the curriculum and improve student management. Implementation of the framework needs to address school access to digital resources appropriate for the whole curriculum beyond generic office applications by using central brokerages or application rentals.

5.3.4 Recommendations for future research

The model of stages of development for ICT in school education developed in this thesis has, like all good research, raised as many questions as it answers. In particular there are matters of generalisation, verification and greater discrimination to be explored.

R1: This study could be extended by examining policy exemplification and communication material.

The main sources of data in this study have been national policy documents, and expert panel and school case studies. Although the national policy documents were easily identified, it became apparent during the research that they were regarded as subsidiary for the classroom teacher: “the statutory bit, the definitions, which I would have done in 10 point Courier” (NM192). In addition there were schemes of work and other exemplification materials which were considered more relevant to daily teaching (Thomas & Bitter, 2002). A comparative examination of such policy dissemination materials may provide data more grounded in practice.

R2: Further research should be done into the building of social capital and personal networks using current school resources, while academic learning is increasingly displaced into self-directed flexible delivery modes.

This study found growth in virtual schooling which can supplement school-based learning and support a greater proportion of independent learning. This may free time for exclusively socialisation oriented activities and there would be a good case for students to spend some of this time working in independent teams on projects seen as more relevant to themselves, where teacher leadership was expressed in a less-directive way. For example, West (2000) sees the future Australian student as one who may pick up social, sporting and cultural skills at a neighbourhood learning centre and combine this with some online tuition at home. Further investigation into a similar educational concept is being undertaken by Jolly (2002).

This line of inquiry can be seen as a section of social informatics research which has previously been scattered in journals of several different fields (Kling, 2000). Some of this work is particularly relevant to school education, and a discussion paper (Department of Education, Employment and Training (Victoria), 2000) looked at some of the social implications of on-line learning for post-compulsory students. Ten percent of innovations involved off-school sites, but significant breakthroughs were restricted by the constraints on school operations (Cuttance, 2001, p. 208). When learning *through* ICT (as opposed to learning *with* ICT), outcomes were broader than

those specified in current curriculum frameworks. This debate about social and curriculum outcomes needs to be extended to examine the opportunities and difficulties for younger students, particularly when handheld wireless ICT increases mobility and convenience (Atputhasamy, Wong, Phillip & Chun, 2000).

R3: Study of barriers to the adoption of ICT in school education should identify ways to eliminate these.

Major barriers identified in this study were the lack of policies relating home and school-based ICT (Becta, 2002), and the lack of alignment between policies for teachers and students. These could be investigated using a series of case studies of schools where home access was brought to all students, perhaps using the ‘Tools for Schools’ model (Pennington, 1999, p. 37; Smithers, 2000). The study could be conducted using a multi-site cross national methodology based upon that of Venezky and Davis (2002). This would explore conflicts such as those found by Fitzgerald & Fitzgerald (2002) when independent learning systems in the Australian Capital Territory were not perceived by students as being supported by their teachers, despite the finding that student progress was much improved by the use of such systems. The proposed model can be used as an organising metaphor to classify the different approaches of schools.

R4: Research is needed into the future implication of ICT for curriculum reform.

The importance of the link between student outcomes and substantiation of the pedagogical rationale was identified in the current study. This link is subject to constant change because of the high rate of change of ICT (Moore, 1997). For instance, voice recognition systems deployed with common generic office products (Microsoft, 2003) could fundamentally alter concepts of literacy by increasing student writing speeds by a factor of ten (Fluck, 2000b). Speech activated language translation systems could have similar implications for foreign language teaching (Universal Translator, 2001). Yelland (2001) noted the need for curriculum reform in the light of ICT, supported by comments such as: “we are fitting new technologies into old curricula which were developed prior to their existence” (Kozma, 1994, p. 8)

and “if technology makes it possible to teach difficult central concepts earlier and with greater understanding, then the traditional sequence of topics needs a complete overhaul” (Tinker, 1999, p. 2). This research could proceed through experimental studies following product-specific teacher professional development.

5.4 Endnote

The field of ICT in school education is maturing rapidly, and in the time of this study from 1999 to 2003 many changes have taken place. Virtual schooling has grown rapidly, becoming part of mainstream school education in many cases (Annells, 2000; The Le@rning Federation, 2001; Thomas, 2002) and a research topic in its own right (Clark, 2001). There is an urgent need to examine the effect of autonomous learning mediated through ICT using metrics of learning success that are not limited to conventional learning outcomes. The interaction between these two aspects may require a methodological innovation which it is hoped the model proposed in this thesis may facilitate.

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Appendices

6.1 List of interviewees

National Experts
<p>BM Centre for Research into Teacher Education Faculty of Education Open University United Kingdom 10th November 1999</p>
<p>DM Executive Officer for Research and Development, International Society for Technology in Education 1787 Agate Street, Eugene, Oregon, United States of America. 3rd November 1999</p>
<p>EM Director Tiger Leap Project Sakala Street 23 Central Tallinn, Estonia 25th November 1999</p>
<p>KB Teacher Training Agency Portland Place, London 12th November 1999</p>
<p>MR Consultant, OFSTED inspector Teacher Training Agency At Swallow Hotel, Northampton, UK. 11th November 1999</p>
<p>NM Schools Director Becta University of Warwick, Coventry, UK 17th November 1999</p>
<p>TE PHARE-ISE, Sihtasutus Archimedes, Kompanii Street #2, Tartu, Estonia 23rd November 1999</p>

School case study interviews
<p>BJ Computer Coordinator South Eugene High School 400 East 19th Avenue, Eugene, Oregon, USA 5th November 1999</p>
<p>CI Computer Coordinator Tadcaster Grammar School, UK, 17th November 1999</p>
<p>KM Computer Coordinator Applecross Senior High School Links Road, Ardross Perth Western Australia, 6153 17th September 2002</p>
<p>SP ICT Coordinator Winthrop Primary School Jackson Avenue Winthrop WA 6150 Australia 18th September 2002</p>
<p>SS Computer Coordinator Theodore Roosevelt Middle School 680 East 24th Avenue, Eugene, Oregon, United States of America 4th November 1999</p>

6.2 School observation case studies

This part of the Appendix contains case studies derived from school visits in each of the four main countries visited. The schools visited were:

United States of America:

Case Study 1: Theodore Roosevelt Middle School

Case Study 2: South Eugene High School

Estonia

Case Study 3: Lyceum Descartes

Case Study 4: Pärnu Nüdupargi Gümnaasium

England

Case Study 5: Tadcaster Grammar School

Australia

Case Study 6: Applecross Senior High School

Case Study 7: Winthrop Primary School

Each of the case studies is organised in the same way, with these main sections:

Background information: giving the basic demographic statistics and recent history of the school situation.

Policy formation: noting the relationship between internally developed policy and those imposed from outside the school.

Implementation and practice: operational details and vignettes of classes observed.

Professional development: ways in which teachers are trained to use and deploy ICT as a learning resource.

Stage of development: an assessment of the relative stage of ICT use in teaching and learning.

Issues arising: summary of the major findings from this case study.

6.2.1 Case Study 1: Theodore Roosevelt Middle School

Figure 8: Theodore Roosevelt Middle School



6.2.1.1 Background information

Age Range	11-14	Students with home computers	90-95%
Enrolment	770 (mixed gender)	Student:computer ratio	6.16 : 1

Theodore Roosevelt Middle School lies in the city of Eugene in the state of Oregon on the western coast of the USA, north of California at about 45° of latitude. Eugene is a city of approximately 130,000, with another 130,000 in the surrounding Lane County. Eugene is Oregon's second largest city, covering approximately 36 square miles, with the Willamette River running through the heart of the city. Governed using the council/manager model, the city runs a regular series of plebiscites, which have legally binding results. City council meetings are televised on the cable network, with teen council meetings treated the same way to facilitate understanding and involvement in decision-making across the population. A significant proportion of the school students (17.5 percent) was enrolled in the French immersion program at the school. 13.3 percent of students were eligible for free or reduced fee school lunches, indicating a relatively prosperous catchment area.

One of the educational destinations for school leavers was Lane Community College. This college had its main buildings in the centre of town, where it ran a large number of face to face programs as well as in suburban centres. Some courses ran as tele-courses on-line. The clerical staff of the college informed the researcher that these were very popular, generating as many enquiries as the face to face courses.

On the day of the observation visit, the school was engrossed in an examination of the way in which students selected option course subjects. While other schools used a computer-based system, Roosevelt continued with the day-long drop-card arena registration method. The process involved each student considering a list of electives, and meeting with the course teachers to ask for a place in each class they have selected. After a period when students place their choices, any over the size limits of the class are “bumped” and these students had to select an alternative. The process proceeded until everyone had a full quota of classes. Various bodies within the school seemed to be vocal in their support or criticism of the system (Enos, 1999, p. 7).

6.2.1.2 Policy formation

State educational standards were maintained through a series of state-wide tests for students in grades 3, 5, 8 and 10 (for the Certificate of Initial Mastery). These were computer-marked multiple-choice tests combined with performance assessment essays. Performance on the tests was considered important, and the school district published aggregated student learning outcomes in the context of comparative figures from other districts and states on its website (<http://www.4j.lane.edu/>).

Figure 9: SS, computer coordinator at Roosevelt Middle School



SS was the computer coordinator for the school. He had become a teacher after working in the computing industry and had worked in the school for 15 years. SS taught mathematics, “the computer projects class and 6th grade explore [sic] ... SS likes Roosevelt because of the freedom teachers have to teach what they want and to teach it the way that they want” (Schwarz, 1999). He considered the facilities in the school to be extremely good, including very high-speed connections to the Internet (such that the author was able to access his web site in Tasmania with greater speed than if he had been sitting at his office workstation). The quality of the IT infrastructure in the school was having a distinct effect upon the kind of skills the students were learning. Even the introductory course included some key skills for accessing the Internet, and some creative elements requiring powerful machines and high-quality software.

SS: All 6th Graders take a 6 week introductory class where they learn how to use the computers at Roosevelt, how to navigate the network, they learn keyboarding skills. They do some multi-media authoring and they do some e-mail. Basic things like that. Beyond that there are electives that include web-design, a little bit of programming, more multi-media design – that’s available for 6th, 7th and 8th Graders. (SS2)

The organisation and management of this IT infrastructure was mainly under the control of SS, with additional technical support. However, the responsibility for determining policy direction was managed by the school through a school policy committee. This ensured the involvement of a wide range of teachers, and the representation of a mixture of skill levels and curriculum areas. He commented that

“We have a technology committee, which meets twice a month. And basically we set the technology policy and standards for the building” (SS6). There was some discussion about the benefit of national standards, especially those which had been developed nearby. SS was aware of teacher burn-out and dissatisfaction with the continuing stream of new policies in almost every area. He discussed the pendulum swing between competency- and norm-based outcomes:

Another teacher made the comment that teachers are distancing themselves from standards development, since competency based outcomes had been used previously, and had been dropped, so there was little desire to repeat a similar fruitless exercise. (SS10)

SS estimated that between 90 percent and 95 percent of students had a computer at home. However, his reading of the situation was that staff knew of some students who did not have this kind of facility, and, even though the vast majority of students were also able to access the Internet, teachers would not require Internet access for work to be done outside school. This issue of equity was not tested by the school in a factual way, but remained a strong impediment to developments in this area because of teacher expectations and attitudes.

AF: Question 8: Do your policies cover the relationship between home and school computing?

SS: Teachers would not expect students to get information from the Internet at home, but they know many students would provide it. [For] Anything that requires students to use computers, they would provide time in the computer lab. (SS19-20)

Although the school was not responding to externally imposed ICT policy, it was likely that the testing regime would determine much of the learning activity in the classroom.

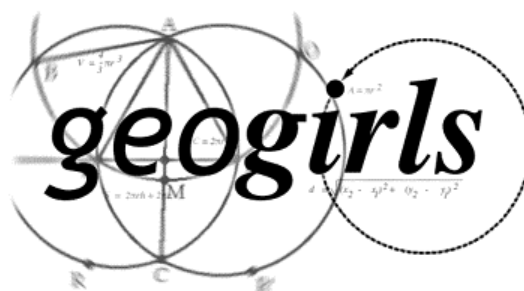
6.2.1.3 Implementation and practice

NN was taking a Mathematics class of 19 girls and nine boys 12-14 years old where they were studying pre-algebra. NN said they would normally use the computer for research and independent learning during the course of a week. In this lesson the students were directed to the web site <www.jenine.org>, and asked to work through the geometry-based who-dun-it problem solving exercise there called ‘GeoGirls: The

Perfect Crime’. This was demonstrated by the teacher using an LCD tablet over an OHP. They had to work out from the story and clues which thief had stolen the Rhombus Gem.

They were challenged to design over a 4-week period a similar exercise based upon algebra and pre-algebra. The design work would be shared by all, and a pair of expert students would implement the web-site that resulted. When asked their opinions of these computer-based learning activities, the students expressed great enthusiasm (“cool!”). Some said they undertake learning activities related to classwork using computers at home. For example, one student said he had made a slideshow comparing television programs for a project using PowerPoint. Quite often he used the Internet to research assignments, and then word-processed them.

Figure 10: Logo from mathematical mysteries web-site.



<http://www.efn.org/~kinne/geogirls/questions/story.html> =
<http://www.jenine.org/geogirls/index.html>

Teacher DM2 was observed teaching two lessons. The first was to 25 twelve-fourteen year old students undertaking learning activities in astronomy. The web-site being accessed was at data.4j.lane.edu:59/WebSearch2000/contest-list.html where a competition was in progress. The students had been allowed to access an astronomical telescope at Pine Mountain which permitted remote operation over the world wide web after they had participated in a web-based training exercise. This activity was entered by DM2 into a competition for teachers, and had won her the prize of eight computers used in the second lesson (SS9). The second class included 28 twelve-fourteen year old students. Under the topic of searching for extra-terrestrials, they studied Science and in particular, Chemistry. This was done by looking at the science behind attempts to seek out extra-terrestrial life, such as the spectra of chlorophyll, the

interpretation of satellite images (What does a typical vulcanised region look like to a satellite?) and so on. The class was undertaking a circuit of nine activities as follows:

- Seeing in a new light (spectroscopy)
- What's a Fossil? (making your own fossil)
- Canned Heat (black body radiation)
- Photosynthesis/Elodea (oxygen production by an organism in a test tube)
- A solvent for life (water analysis)
- Micro-world/Micro-fossil (microscope use)
- It's Alive (satellite data analysis - applying what we know about satellite photographs to pictures of Pluto)
- Space Oasis (read on-screen and summarise)
- Stormy Mars (water cycle/earth timeline - read articles and do comprehension worksheet)

Three of these were computer based using the modes of researching and problem solving. The components were being tested as part of a proposed commercial publication to be called 'Astronomy Village 2' (voyager.cet.edu). Many of the activities observed involved the student finding and reading text on-screen then answering comprehension exercises on paper worksheets.

Figure 11: Science laboratory with circus of experiments, some of which are computer-based.



In another classroom teacher KF was teaching social science to 31 twelve-fourteen year old students. This was a class on Ancient Egypt. There were several activities for students to do. One was to produce their own ancient papyrus, ageing the paper, and using vivid colours, including gold, to illustrate the hieroglyphics they put onto it.

Another activity was to use the eight computers in the classroom to run the Microsoft simulation program 'Age of Empires' and get the information needed to fill in a worksheet which required students to summarise information about the general period, and the specific functions of certain members of the social structure. When asked to illustrate the reaction of students to the integration of ICT into their learning, KF said that they tried to stay behind after class to continue their process of building an empire on the computer. This was not usual in her other classes!

6.2.1.4 Professional development

The school did not appear to have a consistent approach to ICT professional development. The district calendar showed one day per year for systemic PD, and one day per year for school-based PD. However, the researcher was told by SS that most staff based their professional development around the requirements for teacher registration renewal. Most ICT training was sourced and undertaken at a personal individual level.

6.2.1.5 Stage of development

ICT was integrated into classroom practice in ways which made existing subject study more interesting or more motivating. However, there was little evidence that the content had changed and learning continued to be based upon large group instruction in subject classroom spaces.

6.2.1.6 Issues arising

- To what extent does school administration model the integration of ICT into its practice, and how does this affect student attitudes to integrating ICT into learning (especially when other schools have computerised their option course selection and Roosevelt Middle has not)?
- There was considerable lag between the publication of national ICT standards for teachers and students (International Society for Technology in Education, 1996 & 1998) and their adoption by the educational district for Roosevelt school (Russell, 2000).

- Particular teachers (such as DM2 & KF) have been able to make a considerable impact upon the learning of their students by using ICT to make linkages with external facilities (e.g. astronomical telescopes) and blending computer-based and practical activities in the same lesson.
- The use of web-based activities (e.g. by NN) was increasingly making it possible for students to undertake them outside the school premises. This prepared them to use this learning mode in further study at Lane Community College.

6.2.2 Case Study 2 - South Eugene High School

Figure 12: South Eugene High School



<http://www.sehs.lane.edu/>

6.2.2.1 Background information

Age Range	14-18	Students with home computers	70%
Enrolment	1839 (as at Nov98)	Student:computer ratio	19 : 1

South Eugene High school is officially described on the County web-site as follows:

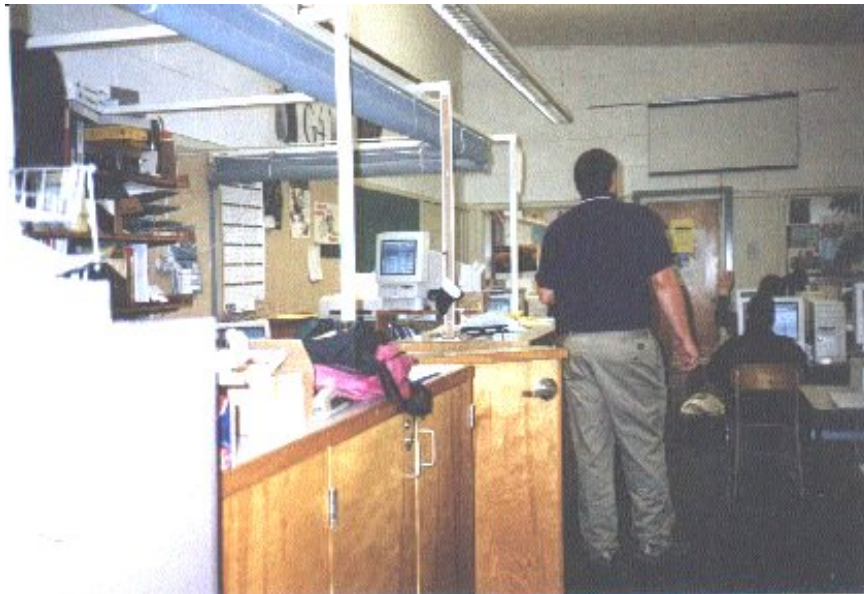
South Eugene is recognised by the U.S. Department of Education as a premier high school in the nation. ... Computers are incorporated in an interdisciplinary fashion, allowing students to use contemporary technology in their academic explorations. Two computer labs are available to students with Internet access and e-mail service. (<http://www.sehs.lane.edu/>)

The generation of income through student-run businesses was particularly important to the development of information technology in the school, with a significant number of workstations paid for through Yearbook sales (to members of the school community). On the other hand, it was astonishing to the researcher that nearly half of

the student workstations had had TCP/IP protocol stacks disabled to prevent Internet access in locations that were not permanently supervised by staff to ensure compliance with school policies on acceptable usage. The previous information technology teacher, Tom Layton had left South Eugene High, to set up the CyberSchool for the District.

6.2.2.2 Policy formation

Figure 13: Computer laboratory at South Eugene High School.



The computer coordinator (BJ) responded to an initial enquiry by the researcher about policies for the cross-curriculum use of ICT by examining the mechanisms in place to control and monitor student access to the Internet. It was clear that this was a topic of some debate within his context, and this was why the question had been misunderstood.

We have a 4J policy that covers the entire district. To break it down, and keep it simple, what they want to do is to make sure kids are getting free and safe access to the Internet, and they kind of break it down in to age groups, in terms of; in order to get an e-mail account, if you are in grade school or middle school, you have to have your parent's permission. And then it has to be teacher permission too. But in High School, it is just parental permission. That's going to be a sticky issue for me, because kids now can go out on Hotmail, Yahoo, and get their own e-mail account and I have no idea if they have their parent's permission. ... (BJ2)

A second enquiry indicated that there was no general policy at the school level for integrating ICT across subject disciplines, but this was happening to some degree. This process was very much centred upon BJ's custodianship of the principal computer laboratory. This custodianship was important because it was a role handed to him by his predecessor, and because of the scarcity of computer workstations.

Well, what happens here is that, if a teacher wants to come in and use the lab, which is the best format for them, because they've got a whole bunch of computers in one area, and you can put in 30 or 40 students, they are going to come to me with a design, or an idea for a design, in their program for a one day, a three day, whatever, project. And then I kind of walk them through that in terms of... (BJ 4)

On the one hand BJ saw his role as that of facilitator and design consultant, yet on the other hand his role was more that of a gatekeeper to the technology. This mediation process was emphasised by the design of the laboratory he kept. The raised dais of the control centre, and the shuttered-like appearance of the framework around it, gave a commanding view of the workstations used by students. See Figure 13. One of BJ's concerns was the differential between the degrees to which the younger teachers incorporated IT into their lessons, compared to the much lesser degree of inclusion by older staff members.

BJ: And they do. They come to me a lot; it's a new thing, for teachers here. Before I was hired, there was not a lot of use of the lab unless there was a very computer savvy teacher. We are also facing a transition, nationwide, and especially in Oregon, for people are retiring, and so we are getting a lot of younger teachers. And the younger teachers come to me a lot more, than the older class teachers do. (BJ5)

BJ was able to make a link between the extent of policy influence, and the source of funding or resources. He indicated that local funding had been predominant as much as 10 years ago, but this had moved to an amalgam of State and Federal funding initiatives over that period. In his view, this meant that these higher levels of government now had a much greater influence upon policies and their implementation than previously. There was a very clear alignment between participation in Federal programs, for instance, and the adoption of policies produced at that level of government.

AF: Question 3: What policies are there at school district, county, state and national levels that contribute to the way in which IT is used across the curriculum in the school?

BJ: Right now there isn't, although I think as more funding is..., because 80% of our school district funding comes from the State-Federal level. That's a big reversal from 10 years ago. So instead of being based upon your local taxes, you're getting everything from the state level and the Federal level. I suspect we will see that, but right now we are not getting a lot of impact from them, other than in the media. They don't have a big list of things we have to do, this way.

AF: Have you seen ISTE's NETS standards?

*BJ: Yes, I have seen those. And part of that is because almost all, a lot of their money came, the grants they got, were Federal. So when you start getting the Federal grants, you got to start playing by the Federal rules. Now, we currently don't have any big Federal grants going on in this building, ... if we did... we'd have to start dealing with it.
(BJ9-12)*

The student computer ratio in this school was far higher than the national average, at about 19 students per computer. BJ's view was that only two high schools in the city came even close to the national average for this ratio, and in the case of South Eugene High, one-third of the available machines were not connected to the Internet. He realised that sources of funds for new technology needed to be made to flow more readily into his school, and part of the reality of the situation was that private, and commercial sources, would be as important in the future as government funding.

AF: Not just capital money, but continuous money, to keep up to date.

*BJ: The only newer computers are in the labs, where we have made a conscious effort to keep up. The exception is in the publications area, where she raises money through advertising, that's where half her money came from over the last two years to upgrade her machines. We don't quite have the same opportunity. I'm looking to see if we can advertise on our web-page, but I don't think we will be able to raise the same kind of money.
(BJ21-22)*

The atypical student computer ratio contrasted badly with the other perceptions of the school within the community. Students were perceived as being willing to do extra study, not just whatever it took to pass the class. A very high proportion went on to

college each year, so there was a common understanding of the developmental pathways that they were progressing along. The proportion of older and more experienced staff was therefore perhaps higher than in other similar schools. BJ considered that this situation had contributed to the funding crisis:

My other battle is ... these are older teachers, and they have no interest whatsoever in giving up money for computers because they don't use them in their curriculum. (BJ 20)

BJ believed computers were going to be integrated into many school learning areas, and he was strongly supportive of this. This led him straight on to considering the CyberSchool in the area, which had been promoted by his predecessor and was designed to facilitate home and extra-curricular learning activities. The researcher considered that a critical value for the success of such a venture would be the penetration of home computer access. BJ's reply was interesting in two ways; because of the great extent of good quality home computer access, and the subsequent perceived impact upon the home-school relationship. By contrast the school was a much less computer-rich environment:

AF: Yes. Question 7: What proportion of the students would you estimate have access to a computer outside school?

BJ: About 70%. A lot of the kids in this school have access to computers at home. After the summer break, I have kids come in with \$5000 systems - and all I can say is you're lucky you've got a lab in school you can come to!

AF: Question 8: Do your policies cover the relationship between home and school computing?

BJ: That's a new area for us. We are trying to do that. I think our biggest issue is that we don't have a big enough communication with the parents and what their kids do with computers at home. Now that's something parents should know. I think Johnny or Jane go up to the bedroom and start doing their own thing, and those parents have no idea what it really is unless the kids say, here look what I did! And that's a big battle, getting parents involved with what's going on.

AF: How about sending attendance home by e-mail

BJ: Well, actually, we're starting a new pilot program called Achieve.com. (BJ31-36)

The high proportion of students with access to a computer at home contrasted starkly with the low levels of access in the school environment. To exacerbate this further, the really expensive and powerful systems at home contrasted with the computers available in the school, which were generally five years old, and which no longer functioned very well, if at all, with the newer software. This situation illustrated technology operating as a driver, whereby the school was under pressure to implement change.

6.2.2.3 Implementation and practice

The <Achieve.com³> website mentioned by BJ was a commercial activity aiming to facilitate, and thereby profit from, links between home and school. This commercial venture hoped to fill a market niche by providing database management functions and by hosting school records in a protected environment. BJ was quite enthusiastic about this, because he saw it as providing facilities he would otherwise have to invent and maintain at the local school level. He was willing to participate in a trial of the system to gauge the reaction of both the school and parental community.

SB was the Publications teacher at South Eugene High. She ran the journalism classes, and taught classes that produced the Axeman monthly Newspaper, and the Yearbook. The latter sold for about \$20. This was an important revenue-raiser for this area of the school, providing good access to new ICT equipment.

³ Achieve.com appeared to have become <http://teacherweb.com/> in April 2003, offering a range of online services to teachers, parents and students.

Figure 14: Logo of South Eugene High School used for newsletter.



These last two operations are supported by the school by allowing English credit (every student requires a minimum of 3 years English credit to graduate) for the Journalism classes. SB requires the students to have passed her Journalism course to start work on the Newspaper. There were no entry requirements for working on the Yearbook, which attracted elective credit.

When asked about the way in which her courses relate to District policies for computers across the curriculum, SB answered “What policies?!” The only one that might apply, about Internet safety, was not relevant to her class machines, since they were no longer connected to the Internet. She asked for them to have this facility disabled since she could not supervise them all the time, and students were more disturbed by MUDS and MOOs than she felt worthwhile. There were no systemic assurances that students should reach a defined level of computer literacy. When asked if she knew about NETS (ISTE) she said she was ignorant of this.

When asked about the number of students who have computers at home, she said that in the last couple of years it had become easy to teach her Journalism class about PageMaker. This was because nearly half of them had already learnt to operate it at home, and she found they taught the other half of the cohort very quickly. In general, students got their keyboarding skills in Middle School, and there were no specific classes in High School. There were many students however, who still needed the

opportunity to obtain or refine these skills. Speech recognition software such as Dragon NaturallySpeaking was not available in the school.

6.2.2.4 Professional development

At the time of the research visit, professional development was considered a personal responsibility for teachers. However, some time later the involvement of the State had resulted in directives to the school site council requiring it to “develop plans to improve the professional growth of school staff” and to “administer grants for staff development” (South Eugene High School Site Council, 2002). The computer coordinator gave a very limited amount of peer training:

[Younger members of staff]... are a lot more comfortable with the technology. I put together a couple of seminars every year, trying to induce older teachers to come in and start experimenting. (BJ6)

6.2.2.5 Stage of development

In this school there were difficulties with integrating ICT into more than a narrow range of subjects. This range was mostly concerned with the study of ICT, or with learning the specific skills to operate ICT (e.g. in the desk-top publishing classes). The difficulties related to the relatively low student:computer ratio as this gave the computer coordinator a significant gatekeeping role to ensure none lay idle for long. The low level of access was exacerbated by the policy requiring every Internet-connected workstation to be visually monitored by a teacher. This had the effect of reducing the number which were fully operational in this sense to half the workstations installed.

Limited equipment and internet access inhibited the integration of ICT into all curriculum areas, and hence the school was not assimilating it fully into teaching. Much of the student use of ICT was concentrated on ICT-specific subjects, which dominated the available computer laboratories.

6.2.2.6 Issues arising

- Staff at the school felt the only significant ICT policy concerned appropriate use of the Internet and the restrictions this made necessary.
- Third party service providers were emerging to facilitate the relationship (through electronic mediation) between the school and its community.
- The CyberSchool was emerging as an alternative non-campus specific authorised alternative to conventional schooling.
- Progress appeared to be limited by a relatively poor student:computer ratio and restricted Internet connectivity.

6.2.3 Case Study 3 - Lyceum Descartes

Figure 15: School logo for Lyceum Descartes

Tartu Descartes Lyceum
 Anne 65,
 50703, Tartu-7
 ESTONIA



6.2.3.1 Background information

Age Range	6-18	Students with home computers	15% (including parent's work computers)
Enrolment	1000	Student:computer ratio	45 : 1

Lyceum Descartes is a school in the southern town of Tartu (see Figure 27). Well established Tartu University is a major employer in the town, which has a population of about 150,000. One guide wryly pointed out that having the University 240 km from the capital suited both politicians and students very well: the government could aspire to liberalism, knowing that student radicalism could not threaten the capital.

Figure 16: TE in front of Lyceum Descartes



The school building dated from the time of Russian influence, and this was reflected in its architecture. Another school stood just 200 metres away, and the two were physically indistinguishable. Each was a featureless blockhouse, some 100m long and 4 stories high, constructed almost throughout of solid concrete. The schools were in featureless grounds, with no sign of play equipment for the younger pupils, although good-natured construction of snowpeople was in evidence in late November. The design is partly determined by the environment. The whole of Estonia is a very flat country, with just one peak reaching a mere 300m. Windswept, except where massive co-planted birch and fir forests give shelter, winter comes early and with intensity. The river freezes over in Tartu by mid-autumn. The interior of the Lyceum is similar to the outside, with a wide internal corridor and classrooms on either side on each floor. Stairs were worn smooth by the traffic, bringing softness to the concrete flagstones.

6.2.3.2 Policy formation

All students use the computers, although only 200 use them regularly. Students in the early years of schooling access a learning environment on the web at www.miksike.ee. Students learning French use them, and Mathematics students use the StudyMaster programs. One teacher of music uses them with her students to study musical history and other topics. Policies governing the use of ICT did not extend to the use of student's own or home-based computers. National policy development in this area had been impeded by a lack of critical mass of computers in this or any other school (TE35). Therefore no comprehensive policy document defining how computers were to be used across the curriculum was available. It was clear that the use of computers was optional (TE42). It was also not accepted as proven that ICT improved education, and therefore the pedagogical rationale was not assumed (TE19).

6.2.3.3 Implementation and practice

Computer provision was situated on the third floor in this school, marking its proximity to the older students. A demonstration room had been reserved for in-

service training, equipped with a video-projector, laptop computer, video recorder and very large television screen. A common room for students aged 17-18 had comfortable chairs and tables, and about 6 computers in the corner, all very intensively used, particularly for e-mail. Although these machines ran Windows, the school e-mail system was normally accessed using PINE, a Unix command line package using a terminal emulator logged into the school server. An off-line capable mail package such as Eudora, or a web-mail system may replace this, but both would require more powerful client workstation technology than available within the school at the time the case study was conducted. Further down the corridor lay the main computer laboratory, with 16 workstations. The layout of this room exhibited good design criteria, with all the workstations around the periphery and provision for a projector for demonstrations at the focal point. It was reported that the room was intensively used, with lessons being so crowded that anyone using a computer had 3 people waiting to use it subsequently. Chairs were highly utilitarian, but the teachers said this was good, because they needed to be strong to take the intensive handling in this room.

Figure 17: Main computer laboratory in Lyceum Descartes, Tartu



A teachers' computer room and a server room adjoined the laboratory. The teachers' computer room had the latest equipment, and was used for activities such as lesson preparation.

As a guide to the activities undertaken by the 200 regular users of the computer facility, the following were mentioned:

- Primary students used the interactive learning environment www.miksike.ee
- Mathematics students used StudyWorks, one of the packages distributed on the PHARE 3 CD-ROM.
- Students have participated in several online simulation activities by e-mail such as Simuvere or Gaia. The latter compressed 8 simulated years into one school year, generated two competing news-sheets, involved the study of ecology and a reunion of those students who had participated.

Discussions with the Computing Coordinator and technical support staff revealed the following ICT set-up in the school. The school web site was www.tdll.ee with the Internet server running on the Windows NT operating system. The school fileserver was an AMD 266Mhx/128M/9G/FreeBSD 3.0 machine, with a programmed replacement being a Celeron 400/128M/12G/FreeBSD 3.3. Space allocation on the fileserver was 10 Mbytes per user, and all students from grade 11 had accounts. All students from grade 8 upwards had e-mail accounts which they accessed using terminal emulators to run the Unix PINE program. Since the server was permanently connected to the Internet on a 1 Mbit/s Interrad radio-link, students with home Internet access through an Internet Service provider could read their mail outside school hours. Others had also enrolled in free web-based e-mail accounts such as Yahoo and Hotmail.

6.2.3.4 Professional development

The PHARE-ISE project was providing specific software training to teachers. This was limited to software which was written for English-language users and was provided by consultants from Scotland and Ireland (TE35). It had been found that good practice was fostered by the use of worksheets to guide student use of generic and curriculum software packages (TE38).

6.2.3.5 Stage of development

The work of teachers had changed very little in response to the availability of ICT equipment for students. The optional status of its use and limited access meant that few students used ICT as a regular component of their curriculum. Since computer-focused courses were the principal use of the equipment for learning, this indicates the school was working at an introductory stage. However, there were indications that some elements of other stages were emerging, such as the investigative use of teacher-created ICT tutorials in Mathematics, home access to student e-mail facilities provided by the school and participation in online simulations.

6.2.3.6 Issues arising

- The parameters for ICT use were low on measures such as student:computer ratio and home access to computers. However, using the figure of 15 percent for student access to computers out of school, there were about six times more computers available at home than in school.
- Independent and online learning was a feature of some computer use, with a website for interactive student work based on worksheets and a tutorial framework program distributed to schools on CD-ROM.
- Professional development was still at the operational stage, with teachers learning how to operate software packages. No clear pedagogical rationale for integrating ICT into the curriculum had yet been accepted, so this aspect had not been incorporated into the training of teachers.
- The use of a wireless broadband link to the Internet was far in advance of many other schools in other countries.

6.2.4 Case Study 4 - Pärnu Nüdupargi Gümnaasium

Figure 18: Pärnu Nüdupargi Gümnaasium logo from school web-site

Pärnu Nüdupargi Gümnaasium
Pärnu Niidu park 12
Pärnu, ESTONIA



(<http://niidu.parnu.ee/>)

6.2.4.1 Background information

Age Range	7-18	Students with home computers	20% (half also have Internet)
Enrolment	430	Student:computer ratio	31 : 1

Pärnu lies at the head of a sheltered bay on the western coast of Estonia. With silver sands on the beach, it was the summer holiday destination of the Russian royal family. Tourism continues all year round based upon the curative muds of the area. The town had a population of 51,807 in 1997 (Cornell, 1999, p. 3). As one of ten schools in this seaside sanatorium town, Nüdupargi Gümnaasium was upgraded to full secondary status, taking groups of seventeen and eighteen year old students from September 1999. Its previous record as a Tiger Leap school had been mainly established with primary students.

Figure 19: Pärnu Nüdupargi Gümnaasium



6.2.4.2 Policy formation

The school's success has been mainly due to a single teacher (VT) who introduced a general curriculum for the integrated use of computers and who used software in imaginative ways. The general ICT inclusion curriculum was originally devised just for VT's own students. It covers a single 45-minute lesson each week. However, all the teachers in the school now use it. VT devised the guideline curriculum without reference to other sources of advice. There is no direct physical link between home computers and the school network, but students are allowed to print out worksheets at school and take them home. Students are not allowed to bring disks from home into school because of a fear of virus infection.

Students normally use the computers for a range of activities. The examples below illustrate the use of ICT for publishing, and the graphics program Kidpix is also used. Some twelve year old students have e-mail accounts, as well as all those sixteen years and older. Students use about 1000 worksheets from the MIKSIKE web-site. Computers are used for problem solving, sometimes as part of educational games, such as memory blocks.

6.2.4.3 Implementation and practice

The school computer workstations are all connected through the local network to the Internet using an ISDN line at 64 kbits/sec. The class started with a short introduction to the task presented using the LCD projector. Students stood around VT as she described how they should open a given file on the network fileserver and use it for a language study. The text was to be analysed to fill in the answers to a crossword in the document, and all verbs were to be identified by underlining. The students are expected to complete this task in 15-20 minutes, and then are allowed to play (educational) games for the remainder of the 45 minutes lesson. In practice, only some of the students finished 10 minutes before the end of the lesson.

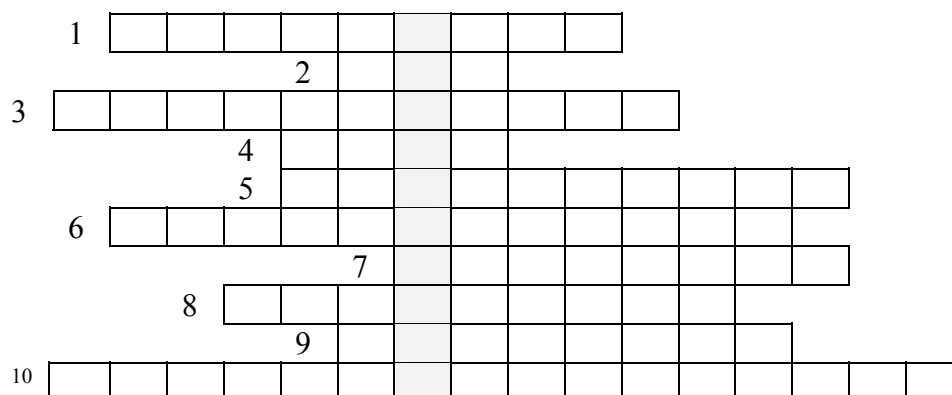
Figure 20: Filling in a crossword constructed from a table in Microsoft Word.



As an example of the integration of ICT into the curriculum, this certainly showed that students were using the equipment. The focus of the learning was on the development of language skills, rather than computer operations. The students were evidently already familiar with the software, and this skill was used as a scaffold for the higher-order language skills the teacher wanted them to work on. In the terms and conditions set by the teacher, it appeared that students would be given an opportunity for autonomous learning once the set exercise had been finished, but it was unclear as to the extent and nature of this activity.

Another group of ten year old students was observed using the computers for a literacy lesson to support their understanding and comprehension of Estonian language and its grammar. A mixed half of the group (thirteen students) was rostered into the laboratory to complete a computer-based crossword which the teacher had created about local coins (see Figure 21).

Figure 21: Example crossword from Pärnu Nüdupargi Gümnaasium

Lahenda ristsõna

Kelle pilt on 5-kroonise peal?

Eesti krooni
valuutavahetuspunktides?

Kelle pilt on 25-kroonise peal?

Mis loom on 5-kroonise mündi peal?

Kes on olnud Eesti Panga president?

Kelle pilt on 100-kroonise peal?

Rahahoidmise koht.

lühend Kelle pilt on 10-kroonisel?

Pank Eestis.

2-kroonise rahatähel olev loodusteadlane.

Ülalt-alla: Eestis käibel olev rahaühik on

Loe läbi teabetekst ning täida ristsõna.

Tabelis liigu nooleklahvidega või TAB
klahviga.

Some teachers give students research activities that require Internet searches. The students are very interested in using computers for learning. Many of them queue up to use them after school. The students might use computer-generated worksheets in Mathematics, Language and English.

6.2.4.4 Professional development

VT was self-taught.

6.2.4.5 Stage of development

It was evident that the demonstrating teacher was incorporating ICT into the curriculum to improve learning in particular areas. This purposeful integration allowed autonomous learning, moving beyond the basic operational skills taught previously. ICT was used in teacher-orchestrated ways, using generic office software in ways which complemented the learning activity. For example, students could type

in answers to the crossword which they subsequently found did not fit, and could delete before trying an alternative. It was not possible to verify the use of these processes among the rest of the teaching staff, but it was likely that the school was beginning to integrate ICT into at least one area of the curriculum.

6.2.4.6 Issues arising

- Generic Office software can be used for learning activities rather than for student creative work provided the teacher is prepared to invest the time to create appropriate materials
- A single self-taught change agent can influence by example the entire teaching staff in their use of ICT
- Autonomous learning was an aim even at this early stage of curriculum integration of ICT.

6.2.5 Case Study 5 - Tadcaster Grammar School



6.2.5.1 Background information

Age Range	11-18	Students with home computers	75%, one-third with Internet access (estimate)
Enrolment	1436 (mixed)	Student:computer ratio	9 : 1

Tadcaster Grammar School lies in its own grounds about 2 km outside the town (population 6,121) in North Yorkshire. Sheltered behind a stone wall, and with car parking among mature trees, it gives the initial impression of seclusion and calm. Some of the buildings date back to a time when this might have been a manor house, but others are of more recent construction. When inspected in 1999, it was a growing mixed comprehensive (all-ability) school (Office for Standards in Education, 1999). A very small proportion of students (2.4 percent) was eligible for free school meals. It had a reputation for good teaching, and standards of pupil attainment were well above average (para. 1). ICT teaching was rated as “good” for all pupils (paras. 5 & 29).

There was a freestanding ICT course in Year 7 for all pupils, providing a very good basis for future work within a limited time allocation (para. 33). Subsequently, subject departments took responsibility for further applications of ICT during Years 8 and 9, and there was further specific ICT work in Year 9 as part of the modular arrangements for art and music. The computing coordinator (CI) had been successful in training many of the other teaching staff to use ICT across the curriculum, although the inspectors reported that this was not yet fully incorporated into curriculum planning. Good multi-media pentium-class computers were available to students [62 older BBC workstations were excluded from the student:computer ratio calculation]. Fifty percent were Internet-connected, through a single shared ISDN line at 64 kbits/s (CI47-53). Since the previous inspection in 1995 the school’s use of ICT had changed significantly:

The Year 7 foundation course is well planned and provides a challenging set of experiences for students. The theme of “children's stories” provides a stimulating focus. Students are introduced to graphic imaging, the use of a digital camera, composition using MS publisher and planning a simple web page in addition to word-processing and other basic ICT applications. Year 7 students, for example, were experimenting with font sizes, colour backgrounds, distorted lettering and page design in the preliminary stages of composing a children's story. The weakness of the foundation course is in the limited time available during Key Stage 3 to develop a comprehensive range of ICT skills. Cross-curricular delivery, considered to be a weakness at the time of the previous inspection, is now a strength.

(Office for Standards in Education, 1999, para. 158)

The core ICT staff had been appointed since the previous inspection and they were well qualified (para. 163).

6.2.5.2 Policy formation

The school's ICT policies were updated annually by an inter-departmental ICT working party chaired by the computer coordinator in March (CI2) and implemented at the beginning of the following academic year in September. The policies were distributed as four documents (see Appendix 6.3.1):

- ‘ICT code of practice’ governing the acceptable use of equipment & services
- ‘ICT Policy’ defining the aims, objectives, review procedures and management structures.
- ‘ICT Development Plan’ detailing the program of equipment acquisition, deployment and maintenance.
- ‘ICT Cross-Curriculum Programmes of Study’ which defines the embedding of the ICT learning outcomes from the National Curriculum into the other subject areas.

There is a strong link between these locally produced instruments and the policy directives from the national government through the National Curriculum. The locally produced policy in some ways pre-empted the policy changes foreshadowed for the 2000 version of the national curriculum. There was a short course on entry in Year 7 for students to become familiar with the local school information technology environment. This was the foundation for further uses of ICT in the various subject

areas in the later years of study which were centrally collated and recorded. In the case of Tadcaster Grammar, national policy in terms of the national curriculum documents had clearly penetrated to the classroom level. The stated rationale for this appeared to be the dual requirements to report individual student progress to the Qualifications and Standards Authority, and regular Inspections of schools, to which Tadcaster had responded in precisely the area of this study.

It was apparent that the school connection to the Internet had been the main focus for attention during the previous policy revision cycle, and that most attention had been upon the guidance and control aspects of this, rather than the potential for cross-curriculum projects.

15. AF: Sure. This is a supervisory aspect - what enablers do you have, to guide use in Geography for instance?

16. CI: Not in the policy, no. That's done more through individual departmental INSET and that sort of structure. The policy is a one side of A4, succinct, if you like...

17. AF: Thou shalt not..?

18. CI: Yeah. What not to do, what to do, type of thing. In a way laying down the type of provision that's there so that pupils have Internet access and so on. So it's really outlining the provision and how to go about maintaining that provision.

19. AF: So it's up to the subject departments to decide how to utilise that provision?

20. CI: Yes that's right, in consultation with me. There's a whole program of INSET and, again, the ICT working party is part of that process whereby departments make known their views on particular issues, or make known their views on INSET needs or whatever. I meet individually with departments as necessary. (CI15-20)

The county authority provides various inputs to schools; ICT policy statements, and guidance to schools on how to produce their own policy statement. Since access to the county advisers has to be paid for, the school has minimised expenditure on this activity by essentially giving the ICT teaching staff a central role in ICT policy formulation (CI11) and responsibility for ICT staff training.

6.2.5.3 Implementation and practice

The relationship with the national curriculum had been resolved by collating ICT activities in all the subject departments onto a master grid showing student progress in the ICT program of study. CI showed, for example, how students covered three of the elements in the ICT program within their English curriculum, doing word-processing and desktop publishing. In Geography students used the spreadsheet program Excel to analyse field-trip data and to model weather patterns. Table 15 summarises the cross-curriculum use of ICT at Tadcaster Grammar School.

Table 15: Cross-curriculum ICT use at Tadcaster Grammar School, from Year 8 onwards.

Subject	ICT use
English	Word-processing, desktop publishing
Geography	Spreadsheets for analysing numerical data, charting and weather prediction
History	CD-ROM searches modelling castle construction
Mathematics	LOGO in geometry
Music	Microsoft Musical Instruments Sibelius for writing musical scores
Science	Datalogging Micro-electronics for All (MFA) introducing control technology using logic boards and simulations.
Textiles	Desktop publishing

(CI, 1999)

The layout of the main computer laboratory at Tadcaster was a compromise between space and the needs of teaching. While a projector was installed to give an image of the demonstration screen which was easily visible from the back of the room, the layout did not give opportunity for the teacher to supervise each workstation from a single vantage point. The teaching space was not able to accommodate a range of teaching styles, with only a single seating position available to each student which gave them access to the computers even during demonstrations and other group instruction events.

Figure 22: Tadcaster Grammar computer laboratory plan.



When discussing home computer policies, CI appeared to discover personal contradictory attitudes during the interview. Home computer access was very high, but could not be universally presumed. However, its utility was clearly important and to leave it out of policy or practice would impede development:

64. AF: Question 8: Do your policies cover the relationship between home and school computing?

65. CI: Not [sic]. We have no policies in place at present. One of the main problems has been, and is still, that we don't rely in any way on home computers. A lot of the students will use their computers to complete homework, and/or communicate with school via e-mail. However, we have not been able to build IT in, in any formal sense, to schemes of work, because we cannot guarantee that somebody has access at home. It does not mean, when we are thinking of policies, that we cannot build it in, because it can be a very useful tool. At the moment we don't have a policy covering this. What will happen, probably next term, is that there will be, we are going to do a survey of, if you like, of the proportion of home computers and what use parents want the students to make of them, especially in communication with the school. And I suppose in that sort of sense we will build something in based on that. But initially we will be looking at facilitating communication between home and school rather than with other people. (CI65)

The contradictory attitudes appeared to be resolved as CI was speaking. The resolution evolved into a plan of action to gather information and incorporate this into new policy.

6.2.5.4 Professional development

The proposal from the Qualifications and Standards Authority to have a national scheme of ICT training for teachers was public knowledge on the day of the researcher's visit, but implementation was not due to begin until 10 months later. Therefore in this interim, in-service training (INSET) was the process by which subject departments were able to access computer expertise and then build ICT into their individual curricula.

At this point only about 10 percent of the teaching staff were fully trained (CI27). Teacher professional development in ICT was conducted almost exclusively in-house. There was evidence of success, with the example of Geography teachers getting students to use the spreadsheet program Excel to analyse field data and model weather patterns (CI74-75). However, there was no evidence of transformative applications of ICT, since this training was aimed at covering the requirements of the National Curriculum rather than transforming the subject.

6.2.5.5 Stage of development

There were isolated uses of ICT in most subject areas. Although the entire ICT curriculum was covered by these disparate activities, it was clear that only one or two instances were found in each subject. Therefore, the activity could only be categorised as an early form of integration, since there were many ways in which ICT was not used in each subject. There was no apparent need to do so, since these other modes were 'covered' for assessment purposes in other subject areas. For instance, there was no indication that e-mail was used for encouraging writing, or that simulations and modelling were used in English.

6.2.5.6 Issues arising

- A large proportion of computer workstations were antiquated, and while excluded from the student:computer ratio, would require students to learn multiple systems and cause technical support complications.
- Close linkage between national curriculum and practice obtained by diffusion with centralised accumulated reporting.
- 'Locking out' of some computer uses from certain subjects because of allocation to other areas.
- Emphasis on appropriate behaviours (regulation) in respect of Internet use rather than contributions to the world wide web (transformation).
- Little evidence of transformation except in policies for intranet development.

Case Study 6 – Applecross Senior High

Figure 23: Applecross Senior High School: entrance and logo



6.2.5.7 Background information

Age Range	13-17	Students with home computers	90% (all Internet connected)
Enrolment	1342 (698F, 644M)	Student:computer ratio	4.2 : 1

A majority (52 percent) of the students at Applecross have non-English speaking backgrounds and it therefore runs a substantial 'English as a second language' program (Applecross Senior High, 2002). The school is also a state centre of excellence for tennis, art, music and education of the gifted child. 70 percent of the students go on to University and the school is generally ranked in the top ten government schools by state-wide tertiary entrance results (p. 9). Learning with technology is one of three school priority areas (p. 5). There is a favourable staff:student ratio of 1:14.5 (Education Department of Western Australia, 2002a, p. 4) which is stable, with 45 percent having been at the school from 5-15 years (p. 7). The Computer-Aided-Design laboratory is one of the best in the state, running commercial and industrial level packages (p.12).

6.2.5.8 Policy formation

The school ICT policy, first drafted in 1998, has been progressively maintained by an IT committee which has a voting member elected from each learning area (KM6). In

2000 a systemic ICT initiative provided an opportunity to access significant funds providing the school focused on state-wide curriculum framework overarching learning aims which emphasised the skills students need to locate, obtain, evaluate, use and share information; and to select, use and adapt technologies (KM20; Education Dept. of Western Australia, nd, p. 3; McCarthy, 2000). The school's two IT coordinators have 80 percent teaching loads, funded from this government allocation for ICT, which most other schools put into equipment acquisition. The strategies adopted to support these new policy aims included professional development for teachers to become competent to integrate learning technologies into the curriculum, equipment acquisition and network support staffing. The last strategy resulted in the appointment of a recently retired science teacher on a part-time basis to provide technical support (KM6).

All schools in Western Australia were given a free choice of platform, and this has resulted in the school using a mixed platform strategy with about 15 percent of the student-accessible workstation fleet being Macintoshes (KM24). Most workstations are leased rather than purchased outright, and formal laboratories have both colour inkjet and monochrome laser printers. The Internet connection had recently been upgraded to give broadband high speed access through a satellite dish, and the initial distribution of this resource was to be 150 Mbytes per student per month. The estimated cost was AU\$1,000 per month. All workstations are connected to the school network. The bulk are concentrated in four laboratories, with others in mini-labs associated with the library, and smaller groups of at least six machines in particular subject area classrooms such as English and Art. Staff are supported by about 55 computers, connected to the network using a V-LAN (virtual local area network) to maintain security. Many of the staff have participated in a scheme to purchase individual laptop computers, although some are waiting for this initiative to include the Macintosh platform. The school has started to install equipment to support wireless networking of these laptops.

6.2.5.9 Implementation and practice

A particular issue in Applecross has been the central electronic storage of teaching material. The initial approach was to have a read-only shared drive and staff put

digitised materials everywhere on this. It was re-organised in 2001 into learning areas, and then the year groups. In addition, the library installed an information management system called AIMS used to search for material by author, title *etc.* More recently a digital library system called Masterfile was implemented, which also had an assets management module. This will require a new server, but offers the advantage of being user-aware, so grade 8 students will be shown information relevant to their age-group. Ultimately this information portal will replace the shared drive, and will be accessible from students' homes:

50 KM: What we are endeavouring to do, and this is down the track, is giving the kids access to our library resources and their folders from home. It will happen [in the future] using Virtual Private Networking, so long as it is safely[sic]. We will implement our new library server, and that is what we will use to implement it. Our intranet page has our daily notices as a PDF file, and we put our newsletter on it as well. (KM50)

There is no agreed level of IT skills expected of students from feeder primary schools. The adjoining primary school has recently been given a funding package to explore the viability of a thin-client capable of supporting external access. This provides a very large central server with multi-user software, allowing relatively old or low-powered workstations to connect to the server and run highly advanced software. Therefore, Applecross Senior High is currently in a transition phase where a strategy for dealing with dramatically different skill levels of new students will be devised.

The interchange of data only between homes and the school is permitted via floppy disk or e-mail. One consequence has been a cost to the school to upgrade the standard school word-processing application to make it compatible with files brought from home. Tension about home use of computers was noticeable in the interview with the ICT coordinator, KM:

57. AF: Can we go back to home-school computing. Do students ever get homework set where they are expected to use a computer?

58. KM: *I guess they actually do. I teach Information Systems and Digital Media. I do expect them to do some development at home. I don't specifically say, but the inference is there that you should be able to do this at home. But you obviously can't say that because you can't expect the students to have a machine at home.*

59. AF: *You can have that debate with teachers, when they have to see they are disadvantaging the majority if you don't exploit machines at home. Do you have to wait until you have 99% home ownership before you acknowledge them?*

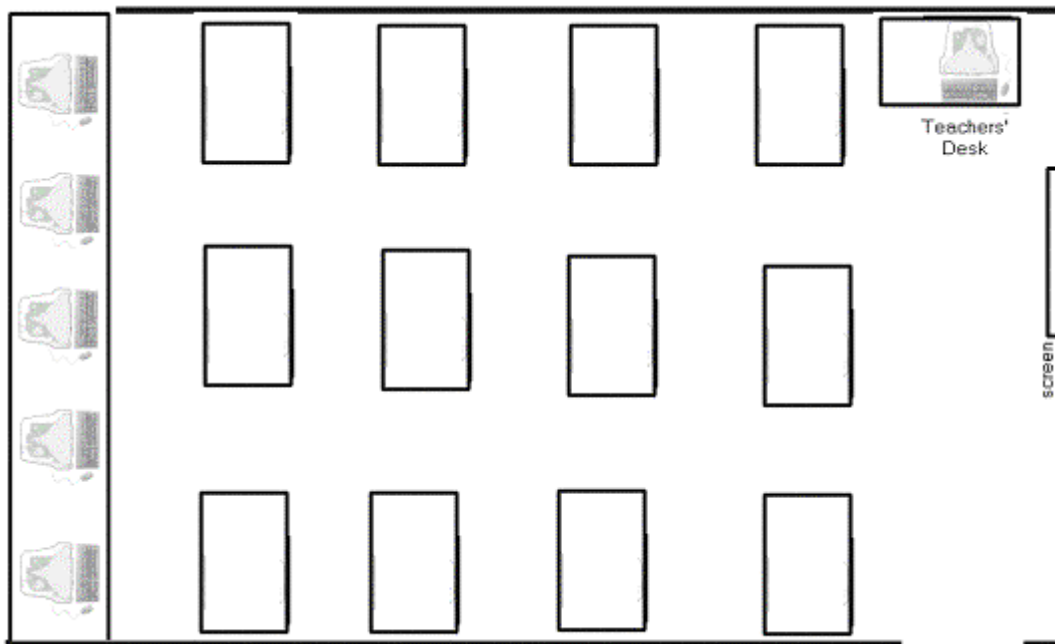
60. KM: *[laughs] Yes! You can go into a class and ask what the current percentage is now. It's a tricky one.*

I teach all upper school subjects. And I am very surprised when I get a handwritten assignment. I actually have only one student who gives me handwritten work – everything else is word processed. Even though it is not stated, virtually everything is done on computer.

For the Information Systems course, sufficient material has been assembled in digital form on a shared access fileserver folder for all the classes for this Year 12 subject. This modularised material is used in all lessons by the students as a resource, in conjunction with a textbook which is replete with internet web-links (such as: www.howstuffworks.com).

HB teaches Mathematics in Years 8-12. He has a responsibility for the academic enrichment program for gifted students in Years 8-10, and he supports this with a small number of computers he has managed to get the school to allocate. They reside along the back wall of his classroom (see Figure 24).

Figure 24: Academic enrichment mathematics classroom, Applecross Senior High.



He uses the computers to support gifted students who are given week-long learning targets, some of which they achieve by using computers at home. He also uses them as part of general Mathematics courses through interactive web-page reference lists (see Table 16) which are accessed by one third of the class in rotation to break hour-long periods into smaller parts, to improve student motivation and to focus on

particular topics. He claimed that twenty percent of his teaching is supported using this technique.

Table 16: Year 11 Mathematics interactive web-site references.

Topic	Web-site References
Linear Functions	http://www.exploremath.com/activities/Activity_page.cfm?ActivityID=18
Cubics and other functions	http://www.univie.ac.at/future.media/moe/galerie/fun2/fun2.html#sincostan
Matrices	http://www.sosmath.com/matrix/system0/system0.html
Probability	http://www.staff.vu.edu.au/mcaonline/units/probability/prorul.html

Students bring their own graphical calculators to these classes, and connect them to the computers. Information can then be transferred from the calculator to storage on the school fileserver, or from a web-site into the calculator. HB directs students to sites such as http://www.casio.co.jp/edu_e/resources/ to download appropriate interactive software that runs on their calculators. HB has found that students are very positive about this use of computers to support the curriculum, and that many undertake learning activities using internet connections at home. His motivation for using these techniques stems from personal altruism and the appreciation of student motivation that it engenders. Also, HB appreciates the increased ease of classroom management. He is of the opinion that this strategy has protected the school's standing in external mathematics assessments against increased competition from new independent schools in the area.

WL takes a Year 10 academic extension class in studies of society and the environment with 5 boys and 29 girls. He integrates computer applications into this class by requiring them to word-process assignments, prepare PowerPoint presentations of different landforms (using images gathered through home internet connection and from a library of useful images that were placed on the school's shared server folder), e-mail climate maps as attachments and construct web-sites: see <www.nhc-entries.com/nhc13/nhc13 & www.nhc-entries.com/nhc33/nhc33>. The students told the visiting researcher that they are generally positive about this mode of learning because:

- It is easier to get information from digital resources than from books (no scanning or other manipulation required to include it in your work)
- Information in digital form is generally more up to date than printed material.
- It is easier to locate and find information in digital format.

Other students demonstrated a web-site they had constructed to show their understanding of the formation and exploitation of petroleum oil (at www.icantbelieveitspetroleum.cjb.net) which required a great deal of work. They estimated they spent 25 hours devising the site, 70 percent of which was done on their home computers.

6.2.5.10 Professional development

Teacher professional development was largely undertaken in-house using local staff expertise. An annual survey derived from a state-wide instrument was used to gather data about the general levels of staff ICT expertise within subject area groupings. This information was used to set up both a general and a targeted professional development seminar series, and to provide point of demand training to individual teachers. The seminar series covered topics which included:

- Classroom computer survival skills
- Introduction to the Internet
- Digital camera and scanner usage
- The more targeted and specialised seminars included:
 - Photoshop 5 for Art & Library staff
 - Web-page design.

Two recent issues were challenging the effectiveness of this scheme. Firstly, new dumb-client advanced technology was being installed in the adjacent feeder primary school, and the flow-on effect for transition students was a factor for which the high school was unprepared. Secondly, a scheme providing laptops for participating teachers had the potential to expand classroom applications beyond the standard office suite. This diversification could require training beyond that which the current ICT

coordinators could reasonably provide. Therefore it was perceived that state government policy was running beyond the capacity of the school's internal policy.

6.2.5.11 Stage of development

It was evident in the case study that integration of classroom-based office-like applications was the pre-dominant methodology. However, there were some glimpses of transformation in the academic extension mathematics and studies of society and the environment arrangements. The regular use of externally created web-based interactive mathematics activities had the potential to make the learning process more flexible, and hence less dependent upon specific times and places. However, the particular implementation could not be seen as different to providing a textbook with solutions in the back. The teacher appeared to reap greater rewards in terms of easier classroom management because of the interactive nature of these online resources. This made the materials more attractive than print-based resources, giving individual and instant feedback to students.

Extension activity in the Studies of Society and the Environment area showed a limited transformation for a few students who worked cooperatively using home-based computers to create an interactive web-site. They indicated that the bulk of the creative task was done this way, with school premises being used for face to face coordination meetings. Although this was a fringe element of the school curriculum, it does illustrate the potential of this way of working at Year 10 and beyond. The school is evidently moving to a situation where its repository (when the underlying architecture has been finalised) of learning materials will be accessible 24 hours a day, 7 days a week from students' homes (KM50).

6.2.5.12 Issues arising

When the school's digital learning materials are available full-time off-campus, the institution may have to confront a series of questions such as:

- Since our materials are now available from anywhere on earth, can students be facilitated in their learning when they take extended holidays?

- How do we decide whether to create our own learning materials; purchase them from commercial sources or use freely available digital materials?
- Do we continue to restrict our student intake to local residents?
- If team-based learning projects which draw upon home computers are going to be used more widely, where do we stand with respect to supervision?
- What will be the final, persistent and reliable system for the central storage of curriculum materials?

6.2.6 Case Study 7: Winthrop Primary School

Figure 25: Winthrop Primary School



6.2.6.1 Background information

Age Range	5-12	Students with home computers	85%
Enrolment	693	Student:computer ratio	6.8:1

Established in 1991, Winthrop Primary School draws students from families in the middle socio-economic group, many on limited tenure appointments or from Asia. Five percent of the students have regular contact with the English as a second language teacher and Mandarin classes for fifty students are held before school (Education Department of Western Australia, 2002b). Ten of the eighteen classrooms were in air-conditioned temporary accommodation on the day of the site visit. There was a very low staff turnover, with many of the original teachers continuing to serve in the school (Education Department of Western Australia, 2002c).

6.2.6.2 Policy formation

Information Technology across the curriculum was a school priority from 1997 to 2000, and this was supported by additional funding through the technology focus school program. The 2002 Learning Technologies Plan for the school (see Appendix 6.3.2) was produced from the annual revision process first started in 1998 when the

Department of Education for Western Australia allocated \$80M to this area (SP2). The staff planning committee had been largely led by the advice of the two ICT coordinators, who had contributed to system-wide professional development on using the Internet in Education (SP16). The committee had also accepted advice from additional sources including commercial consultants. ICT-related learning outcomes were defined for each age group, but these were advisory rather than proscribed.

The future direction of ICT in the school was being determined by a systemic policy to limit equipment purchases to approved models, and a trial of Application Service Providers (ASP) to implement an 'Education to Community (e2c)' model (Kay, 2001).

6.2.6.3 Implementation and practice

In the classes observed, eleven year old students had used PowerPoint in social studies incorporating animations and word processing to create their own evaluation and cover sheets. A progressive science experiment had been photographed and these images were placed into a word processed record. A popular activity was participation in the Quizzard, a regular set of twenty questions about Australia for teams of students to answer in a competition (http://www.palmdps.act.edu.au/resource_centre/wizard_oz/quizzard_intro.htm), which students also accessed from home. There were two computer workstations at the front of every class since this was where the teacher's desk and the network connection points were placed. Additionally each group of four classes had access to a 'mini-hub' of a further six workstations. Teachers were "happy to share their technology" (SP40), so students from any class could use the computers in others reasonably easily. Wireless networking was used to link six demountable classrooms and the neighbouring pre-primary schools into the school network (SP46 & 50). This allowed students to work with the six laptops outside under the trees, but it got slower with distance (SP34 & 50). There was a perceived difference between the way students used computers at home and at school. "We play games. We Hotmail our friends" (SP58).

6.2.6.4 Professional development

A large proportion of the funding for ICT in the school was allocated to professional development since it was “critical to everything we do” (SP12). Much of this training was provided within the school on a “just in time” basis (SP28), since “there is some PD around, not a lot” (SP26).

Professional development in the ICT was limited through the reticence of the coordinator and because of competing programs. The ICT coordinator felt that “I can’t push my teachers any more” and that she had “no right” to tell them what PD to do (SP26). It was “a long process to get teachers to use IT effectively in the curriculum” and “there are some teachers who will not, will not, move into the 21st century” (SP60). The competing demands of the systemic Curriculum Improvement Program (Department of Education Western Australia, 2000) were considerable, further limiting the time she felt teachers could spare for ICT professional development.

Twelve of the fifty-five staff had taken up PC laptops under the Department of Education’s scheme, the small number explained by the incompatibility of these notebooks with the Macintosh platform standard throughout the teaching areas of the school.

6.2.6.5 Stage of development

There was limited evidence of the integration of ICT into student learning activities. While some new technologies such as wireless networking and video-editing (SP60) were in use, the examples observed (creating cover pages and evaluation sheets) were minor additions to the curriculum rather than integral to it. Links with student homes mediated by ICT were not encouraged because of the perceived difference in the way computers were used in the two places. Students were not allowed to develop PowerPoint presentations at home since they could not print out there.

6.2.6.6 Issues arising

- There was tension between the multi-platform policy of the Learning Technologies plans prior to 2000 and the single platform supported under the notebooks for teacher program. This tension was exacerbated at this school through their adoption of the alternative platform for all teaching purposes.
- Some use of wireless networking and laptops.
- Some teachers were “ostriches with their heads in the sand” with respect to ICT, and this was a considerable challenge for the ICT coordinator: “I don’t water rocks” (SP62).

6.3 School policy documents

6.3.1 Tadcaster Grammar School (England)

The four policy documents from Tadcaster Grammar illustrate the way in which one school has chosen to implement the national curriculum requirement to teach ICT in a cross-curricular context. It chose to divide the advisory program of study (PoS) into discrete elements. These elements have then been matched with existing components of other subject areas for delivery, such as a Desk Top Publishing module in Art and a simulation of storming a mediaeval castle in History. Subject teachers record the participation of students in ICT-based activities on a log sheet. The ICT coordinator collates the logsheets and writes reports for individual students for this area of learning. It was noted that this method of delivery can make it difficult to make the cross-subject linkages which digital materials can support.

The four policy documents comprise:

- ICT code of practice
- ICT policy
- ICT development plan
- Excerpt from Key Stage 3 cross-curricular programme of study (Art and History only).

ICT Code of Practice – Tadcaster Grammar

ICT stands for Information and Communications Technology. With regard to this code of practice ICT covers all such technologies used at Tadcaster Grammar, specifically including the curriculum network, stand-alone hardware and peripheral equipment (such as digital cameras).

Access to ICT is provided to support and enhance the student's school work and to provide key skills that will prove useful in future. In using ICT at Tadcaster Grammar, all users must agree to the points below and should recognise that, in doing so, the productive and enjoyable use of ICT will be maintained.

1. General

Students should:

- Consult the Head of Information Technology (Mr Ives) with any problems or queries.
- Act in a manner in keeping with the ethos of Tadcaster Grammar.
- Use ICT solely in connection with school work and extra-curricular activities.
- Be under the responsibility of a member of staff.
- Take care to look after the ICT equipment used.
- Explore the use of the different software packages made available to them.
- Familiarise themselves with the hardware present in school.
- Be aware that computer based viruses exist and work to restrict infection.

Students should NOT:

- Use the ICT rooms without a member of staff present.
- Tamper with ICT equipment, including system files.
- Install any software.
- Play games.
- Eat or drink in the ICT rooms.

2. Curriculum Network

Users are provided with the privilege of a network account as long as they act responsibly.

Responsible users should:

- Follow the advice given on the use of passwords (if applicable).
- Solely use their own personal account, or one of the shared accounts.

Responsible users should NOT:

- Undertake actions that will have a detrimental effect on other network users (including editing, moving or viewing files).
- Tamper in any way with the network system, including hardware and software (that is system files and processes).
- Allow the use of their account or password by anyone else.
- Store unsuitable or irrelevant files.

NOTE: The network administrators reserve the right to view any files stored on the network, and to delete any that are unsuitable. Common storage areas on the network (eg. Drive T - 'Shared on Tadgram' or the root of the 'Home' drives) will be cleaned of excess/unsuitable files on a regular basis.

3. Internet Access

Tadcaster Grammar recognises the importance the internet as an information source and collaborative learning and communication tool. It does not condone access to unsuitable material and implements procedures to restrict and discourage such access. Filtered internet provision is provided using the curriculum network, using departmental usernames/passwords and is subject to the following:

- Access is a privilege at Tadcaster Grammar School.
- Pupils must be supervised at all times by an appropriate member of staff.
- Time spent on-line must be specifically related to current school work and should be sensible and planned.
- Unsuitable materials must not be accessed (incl. viewing, downloading and copying).
- Email should only be used after consultation with the supervising member of staff.
- Users should take notice of matters such as plagiarism, lawful conduct and copyright.

ICT Policy –Tadcaster Grammar

Rationale

Information and Communications Technology (ICT) are an integral part of all areas of modern society, commonly called the Information Age. ICT includes all digital media (such as text, images, video) and systems for information retrieval and publishing, control, collaboration and communication. In order for young people to take full advantage of the opportunities offered by ICT, in enhancing their learning and participating in society, it is vital that ICT capability and confidence are taught as a key skill for all.

Aims

Teaching staff will be confident and confident in integrating ICT into their teaching through productive lesson preparation and classroom access and presentation.

Students will be taught to use ICT effectively to analyse, process and present information and to model, measure and control external events as required by the National Curriculum.

The impact, limitations and opportunities of networked resources (such as an intranet and the Internet) will be realised and used effectively and efficiently.

All ICT users will demonstrate a positive and responsible attitude to ICT and will develop autonomy and independence in using and seeing the need for using ICT.

Students will have suitable access to ICT resources to allow work in discreet lessons and across the whole curriculum and to allow individual and collaborative learning.

Objectives

The ICT Working Party will review and monitor the use of ICT across the curriculum.

ICT work will be differentiated for different ability students.

ICT will be mapped, designated and integrated into curriculum areas, according to the National Curriculum orders and with a view to Key Skills.

Across Key Stage 3 ICT Log sheets will be completed for individual students for all designated ICT work. The ICT Log sheets will be stored as a central record.

Students have prioritised (by year group) lunchtime access to ICT facilities at a published time each week in addition to a range of specialised extra-curricular ICT activities.

All ICT users will have an individual curriculum network username and a fileserver directory for storage of files. They will also have access to floppy discs in order to keep backup copies.

Curriculum network usernames and passwords form the basis for network security and associated capability, such as internet access.

Staff users of the curriculum network and all departments will have an individual username/password enabling filtered access to the Internet and an Internet email address.

Using the departmental usernames, students will have access to the internet, for world-wide web and email, and only under the direct supervision of a member of staff.

Intranet access is provided where internet sites will be cached locally (if possible and vetted by teaching staff) and local curriculum specific content will be created. All curriculum network users will have access to the intranet, with user permissions used to limit access to staff areas.

ICT resource provision will be reviewed annually in line with the ICT Development Plan.

The school web-site will be set-up and will provide relevant information for current and prospective parents, students and staff.

ICT resources will be suitably protected from viruses, tampering and unauthorised access to information. This includes administrative and curriculum areas.

INSET for staff will be provided and participation encouraged both internally and externally, in particular making full use of the NGfL training initiative funded by the New Opportunities Fund.

ICT Technical support is provided according to the ICT Technical Support policy.

Review

Through the ICT Working Party, the ICT policy and development plan will be reviewed annually.

Measures of student ICT capability will be examined annually.

The ICT Working Party will monitor ICT usage and staff competence and confidence throughout the year.

Students and parents will be asked to respond to an ICT questionnaire in the Spring term.

ICT Development Plan 1999-2000 – Tadcaster Grammar

National Curriculum IT Delivery and Discreet ICT

1

- 1.1 Aim: To provide an effective teaching scheme that will develop the necessary skills and experiences to enable pupils to become critical and largely autonomous users of ICT at KS3.
- 1.2 Objectives:
 - 1.2.1 Provision of discreet ICT lessons in KS3 for all pupils every week in years 7.
 - 1.2.2 In year 8 and 9 a mapped, designated system of ICT work to be carried out in all curriculum areas. Such work to be integrated, compulsory for all pupils and recorded and assessed.
 - 1.2.3 INSET provision on the recording and assessment given and incorporated into the whole school recording and assessment policy.
 - 1.2.4 Recording and assessment procedure introduced, to include central recording of ICT assessments from all curriculum areas.
- 1.3 Time-Scale: From September 1999
- 1.4 Implications
 - 1.4.1 Subject staff knowledge of ICT log sheets.
 - 1.4.2 Subject development of ICT activities and log sheets.
 - 1.4.3 Availability of ICT for booking across all 40 periods.
 - 1.4.4 Accommodation for whole form groups in ICT rooms.
- 1.5 Responsibility:
 - 1.5.1 Head of IT, delegated to H Taylor for discrete Yr 7 ICT lessons.
 - 1.5.2 Head of IT with individual subject HoDs for cross-curricular ICT scheme.
 - 1.5.3 Head of IT for INSET, recording and assessment policy.

2

- 2.1 Aim: To provide a valued and useful unit of IT in KS4 for all pupils.
- 2.2 Objectives:
 - 2.2.1 The introduction of an accredited Key Skills unit.
 - 2.2.2 Students to value and participate well in the scheme.
- 2.3 Time-Scale: From September 1999
- 2.4 Implications
 - 2.4.1 Continued time slot for PSE ICT rotation.
 - 2.4.2 Accommodation for whole form groups in ICT rooms.
- 2.5 Responsibility: Head of IT, delegated to H Taylor.

ICT Resources and Software

3

- 3.1 Aim: To provide a common software base across the whole school, which is fully licensed.
- 3.2 Objectives:
 - 3.2.1 Existing computers which are upgraded and all newly purchased computers to have:
 - MS NT 4 Workstation/MS Windows 95/98 (departmental decision)
 - MS Office Professional 97 (including MS Word, MS Excel, MS Access, MS Powerpoint, MS Outlook), possibly MS Works 4.5 as cheaper alternative.
 - MS Publisher 98
 - MS Internet Explorer 5
 - MS Exchange client
 - Virus protection
 - Other departmental based packages (to be decided through the ICT Working Party).
- 3.3 Time-scale: ASAP
- 3.4 Implications:
 - 3.4.1 Cost of licensing.

4

4.1 Aim: To promote the personal usage of ICT by staff in lesson preparation and as professional development.

4.2 Objectives:

- 4.2.1 Make sure that all departments' areas have a workstation for staff use
- 4.2.2 Encourage use of ICT through network/internetwork INSET.

4.3 Time-Scale: Short term

4.4 Implications:

- 4.4.1 Costing of new computers for staff departmental areas (£750 per machine).
- 4.4.2 INSET time.

5

5.1 Aim: To take full advantage of learning opportunities that are available using new technologies.

5.2 Objective, to explore the feasibility and cost effectiveness of new technologies such as videoconferencing, digital image capture (video and still), editing and projection.

5.3 Time-scale: Short term

5.4 Implications:

- 5.4.1 Cost of image capture cards, sound cards, earphones, speakers, scanners, digital cameras, digital video (approximate cost £2000).
- 5.4.2 Training needs of staff.

6

6.1 Aim: To provide a core suite of ICT resources within departments, incorporating a common operating system and capable of making use of new Information and Communications Technologies in all teaching rooms.

6.2 Objectives (in accordance with departmental ICT development plans and as a minimum provision in order to take full advantage of the whole school curriculum network infrastructure funded as part of NGfL):

6.2.1 Upgrade suitable computers to bring them up to at least the following specification:

- 64MB RAM
- Colour SVGA Monitor
- Windows 95 or NT4 operating system (for workstations)
- Network ready (i.e. inclusion of a network card)
- 1.2GB HDD

6.2.2 Replace all computers that are over five years old and/or lower specification than 486 processor.

6.2.3 Purchase of further computers to provide equivalent of one networked workstation per teaching room.

6.3 Time-Scale: Medium term

6.4 Implications:

- 6.4.1 Costing of upgrade parts, replacement and new computers as needed in each department.

6.5 Responsibility: Head of IT, IT Technicians, Departmental ICT Links.

ICT Technical Support

7

7.1 Aim: To restructure and improve ICT Technician support for both the administration network and curriculum ICT provision.

7.2 Objectives:

7.2.1 To appraise the ICT Technicians in order to review their pay and conditions, and job descriptions.

7.2.2 Increase the hours covered to allow a greater degree of lesson support for staff. An increase of 5 hours (to 25 hours) + existing 37 hours would be the minimum anticipated.

7.2.3 Production of a technical support policy to support the work of the ICT Technicians.

7.3 Time-scale: ASAP

Staff INSET and Professional Development

8

8.1 Aim: Develop staff capability and confidence in the use of ICT, in line with cross-curricular ICT provision..

8.2 Objectives:

- 8.2.1 Network training sessions for ICT Links and then all staff, to include Internet capability.
- 8.2.2 Departmental training to facilitate ICT at KS3/4.
- 8.2.3 Key Skills ICT INSET for ICT staff and facilitation of departmental INSET.
- 8.2.4 Time devoted to ICT during INSET days.
- 8.2.5 Time off timetable for departments as necessary to deliver training on departmental software.
- 8.2.6 A weekly slot for ICT consultation on basis of consultation and training as arranged departmentally or individually.
- 8.3 Time-scale: Short term
- 8.4 Implications:
 - 8.4.1 Rooming and access to ICT facilities.
 - 8.4.2 Availability of staff for training and provision of training.
 - 8.4.3 Provision of adequate departmental and staff computers to enable training and follow-up use to reinforce training.
- 8.5 Responsibility: Head of IT

9

- 9.1 Aim: To raise awareness and participation in external ICT training, specifically the INSET structure provided by the New Opportunities Fund.
- 9.2 Objectives:
 - 9.2.1 Identify needs according to National guidelines.
 - 9.2.2 Plan NOF expenditure.
 - 9.2.3 Actively seek courses that are relevant to departments, using material provided nationally and independently from training providers.
 - 9.2.4 Meet National objectives for ICT capability.
 - 9.2.5 Release opportunities through the ICT newsletter that will be released regularly.
- 9.3 Time-scale:
 - 9.3.1 From Summer 1999 for planning expenditure.
 - 9.3.2 Needs identification according to departmental plan, beginning Autumn 1999.
- 9.4 Implications:
 - 9.4.1 Cost of cover.
 - 9.4.2 Number of staff needing time out of lessons, possibly whole departments at once.
 - 9.4.3 Provision of INSET time, and/or twilight sessions for ICT.
 - 9.4.4 Suitable identification of courses and training providers.
- 9.5 Responsibility:
 - 9.5.1 Head of IT, subject HoDs, SMT (Deputy i/c Professional Development)

Access to Networked Resources

10

- 10.1 Aim: To provide a relevant and up to date school intranet site that is integrated into departmental schemes of work, but is also selectively mirrored and developed for the Internet.
- 10.2 Objectives:
 - 10.2.1 Set up a system by which all departments can write their own web based content for the site. This can be personal writing of web pages or by passing processing information for converting to web pages by a central web publishing team.
 - 10.2.2 Make sure that the Internet based site is viewed and of use to prospective and current staff, parents and students.
- 10.3 Time-scale: Spring term 1999
- 10.4 Responsibility: Head of IT
- 10.5 Implications:
 - 10.5.1 Time for web co-ordinator to upload new content and manage the site.
 - 10.5.2 Time and training for staff to become proficient in developing their own web content.
 - 10.5.3 Development of a web-publishing team, comprising staff and students.

Excerpt from Key Stage 3 cross-curricular programme of study (Art and History only) – Tadcaster Grammar

Subject	Activity	Year	PoS	PoS Description	Level	Level Descriptor	Log sheet
School specific subject area	module of work within this area			Advisory programme of study description from national curriculum documents			Internal school ICT recording system
Art	DTP	9	1 a	use IT equipment and software autonomously	5	Pupils use IT to organise, refine and present information in different forms and styles for specific purposes and audiences (level 5)	ICT5Ar9a
			1 b	consider the purposes for which information is to be processed and communicated	using information from a range of sources, and demonstrating a clear sense of audience and purpose (level 6)	ICT5Ar9b
			1 c	use their knowledge and understanding of IT to design information systems, and to evaluate and suggest improvements to existing systems			
			1 e	consider the limitations of IT tools and information sources, and of the results they provide, and compare their effectiveness and efficiency with other methods of working			
			2 a	use a range of IT equipment and software efficiently to create good quality presentations for particular audiences, integrating several forms of information			
			2 b	select appropriate IT equipment and software to fulfil their specific purposes			
History	1066	7	1 a	use IT equipment and software autonomously	3	They use IT ...to access stored information following straightforward lines of enquiry.	ICT3Hi7a
			1 b	consider the purposes for which information is to be processed and communicated			
			2 c	be systematic in their use of appropriate search methods to obtain accurate and relevant information from a range of sensors			
History	Fletcher's Castle	7	3 e	modify the rules and data of a model, and predict the effects of such changes	3	They use IT-based models or simulations to help them make decisions, and are aware of the consequences of their choices	ICT3Hi7b

6.3.2 Winthrop Primary School (Australia)

This example of a school ICT policy illustrates linkage between budgets, staff and student skills, curriculum outcomes and ICT infrastructure:



Winthrop Primary School Learning Technology Plan Strategic Overview

Students: 750

Funding: LTF & special purpose grant \$ 17 193

Strategic Outcomes	2002	Target
Planning	L.T. planning exists within school curriculum plans. Review of vision, outcomes, implementation and monitoring strategies will be undertaken in 2002 to ensure the direction of the school meets the needs of the school community and changing technologies.	<ul style="list-style-type: none"> L.T. planning is linked to school planning and curriculum, is well monitored and responsive to changing technology and emerging needs of the school.
<p>Staff Capabilities</p> <p>Teachers routinely use Learning Technology for professional planning and to achieve learning outcomes.</p>	<ul style="list-style-type: none"> Integration skills for all curriculum areas especially Health and SOSE (C.I.P. focus for year). Basic skills J.I.T. training focus on multimedia / presentation skills - L.T. co-ordinator (all staff) Internet in Curriculum P.D. modules revision for staff. After school P.D. sessions for integration / ideas using peripherals. (use staff teams / buddy system.) 	<ul style="list-style-type: none"> Most staff use a range of Learning Technologies and are integrating these into the teaching and learning program.
<p>Integration & Use</p> <p>Classrooms routinely use a variety of learning technology skills to enhance their achievement of learning outcomes across all curriculum areas.</p>	<ul style="list-style-type: none"> Some staff integrating L.T. into all curriculum areas covered in the C.I.P. P.D. courses and staff who have already developed skills to assist other teachers to achieve this outcome. Extra support by L.T. co-ordinator to continue workshading situations to develop student skills and collaborative learning strategies. <p style="text-align: right;">LTF : \$ 4 000 (includes 20 relief days)</p>	<ul style="list-style-type: none"> Learning programs regularly incorporate Learning Technologies across all learning areas. Most teachers have developed skills in student centred learning techniques incorporating appropriate learning technologies.
<p>Hardware, Software, Connectivity.</p> <p>Teachers and students have adequate access to Learning Technology resources in their classrooms.</p>	<ul style="list-style-type: none"> Total at Standard = 76 Infrastructure upgrade in line with Telco rollout - Upgrade Linux box replace curriculum server LTF \$7200 Software to support SDP & CIP outcomes; Health and SOSE CD roms, Extend application site licences all year levels. Extend Hyperstudio site licences. Extend Inspiration site licences (yr4-7) \$ 1 000 Network account -ISP \$ 1 100 Maintenance of network, computer repairs and independent technical support \$ 1 893 Cabling network extension - wireless support for pre-primary rooms. \$ 2 000 	<ul style="list-style-type: none"> Provision of learning technologies is more than adequate to facilitate daily use by all students in a variety of ways across the curriculum. There is a planned approach to future management of hardware and software requirements and is appropriate to the teaching and learning program. Suitably funded connection to adequately meet curriculum demands.
<p>Student Skills</p> <p>Students demonstrate the use of Learning Technology to enhance their learning within the classroom.</p>	<ul style="list-style-type: none"> Continuum of skills to be developed in all year levels Development of collaborative projects for integration across the curriculum. (web search) Student "experts" to assist in minor maintenance. 	<ul style="list-style-type: none"> A co-ordinated approach to student skills through the use of a skills continuum. Students monitor their own progress on the continuum.
Funding Summary	<ul style="list-style-type: none"> Staff Capabilities LTF \$ 4 000 Hardware LTF & CIS \$ 7 200 Software LTF \$ 1 000 Connectivity LTF \$ 4 993 <p>Total Funding : \$ 17 193</p>	

6.4 Guidelines for interviews with participants in the study

The study used the interview method to obtain data from members of the expert panel, school ICT coordinators and classroom teachers with similar questions appropriate for the perspective of each kind of participant. The questions below were sent to each participant where possible in advance of the agreed interview time. Neutral probes were used to elicit further responses where necessary.

Questions for national level experts (expert panel)

1. Has your country ever had, and does it now have a policy framework guiding the use of information technology by students in all curriculum areas?
2. What is the current form and jurisdiction of this policy?
3. What were the political, policy and administrative forces operating on the process of its gestation?
4. In your opinion, what were the objectives, both stated and covert, of the bodies which constructed, endorsed and authorised the policy?
5. When was the policy authorised at the highest relevant level in your country?
6. What was the process by which the policy was implemented? Which organisations were responsible for which components?
7. In your view, how would you describe the implementation process?
8. To what degree did the implementation achieve the stated policy aims, in terms of depth and breadth?
9. What were the consequences of the implementation pattern achieved?
10. Are revisions of the policy planned, and if so, what direction are they likely to take?
11. Can you comment as to whether teacher professional development initiatives have in general preceded or followed related curriculum strategy announcements?
12. Are there particular schools, documents or other resources you can recommend I refer to as examples of what you have told me?

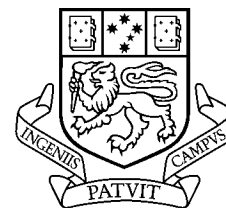
Questions for school ICT coordinators

1. Does the school have a policy for the use of information technology across all subject areas?
2. If so, how was it formed?
3. What policies are there at school district, county, state and national levels that contribute to the way in which IT is used across the curriculum in the school?
4. How many students are enrolled?
5. What are the highest and lowest grades taught?
6. What is the level of computer provision (in terms of the number of students to each multi-media computer), and what proportion of the computer equipment is internet-connected?
7. What proportion of the students would you estimate have access to a computer outside school?
8. Do your policies cover the relationship between home and school computing?

Questions for classroom teachers

1. What are the numbers of boys and girls in the class, and what are their grades?
2. Which parts of the curriculum are computers mostly used to support?
3. What modes of computer use would a typical student in this class normally engage in over a period of one week? (from Publishing, Problem Solving, Communicating, Researching, Independent Learning).
4. What are they doing with computers this week?
5. What do the students think of the way in which they are asked to use computers in school?
6. Do any of the students undertake learning activities related to classwork using computers at home?

6.5 Information sheet



UNIVERSITY OF TASMANIA
School of Secondary and Post-compulsory Education

INFORMATION SHEET

for a Cross-national study of policy-making for
information technology in schools

The objective of this study is to investigate the historical approach to decision-making in relation to the use of information and communication technologies in schools.

The methodology has involved an extensive literature review. This has directed the research into an interview phase, which will solicit information from a range of national, local, and school decision-makers.

Your views will be recorded on tape, with your permission, and transcribed. Some edited excerpts which illustrate pertinent views you have expressed, in a personal capacity, may be quoted in the submitted thesis. At your request, you will be given the opportunity to review and edit the transcript, and anything you change will not be used further in the research.

Name of chief investigator

The name of the researcher is Andrew E. Fluck. The supervisor for this study is Professor John Williamson, School of Secondary and Post-compulsory Education, University of Tasmania.

Purpose of the study

This project is being undertaken as part of (or to fulfil) the requirements for a PhD degree in education.

Criteria for inclusion or exclusion

This study will include your contribution as an informed decision-maker in the context of pupil's use of ICT in schools.

Study procedures

During this study your participation will be limited to a face to face interview. The researcher will send you details of the topics to be covered beforehand.

Possible risks or discomforts

It is not anticipated that there will be any risks for respondents associated with the conduct of this study.

Confidentiality

The data collected will be kept secure by maintaining a minimum of two electronic copies at any one time. The data may be reproduced in full as part of the appendix of the proposed doctoral thesis.

Freedom to refuse or withdraw

Your consent to participate in the study is much appreciated. If you are unable to meet with the researcher, or wish to withdraw at any time, this is understood.

Contact persons

If you wish to contact the researcher, the relevant details are given here:

Andrew E. Fluck	Telephone: +61 3 6324 3284
Faculty of Education	Facsimile: +61 3 6324 3048
University of Tasmania	E-mail: Andrew.Fluck@utas.edu.au
Locked Bag 1-307	World-Wide-Web:
Launceston	http://www.educ.utas.edu.au/users/afluck
Tasmania, 7250	
AUSTRALIA	

Concerns or complaints

If you have any concerns of an ethical nature or complaints about the manner in which the project is conducted, you may contact the Chair or Executive Officer of the University Human Research Ethics Committee. (In 1999 the Chair is Dr Margaret Otlowski, phone (03) 62 267569 and the Executive Officer is Ms Chris Hooper, phone (03) 62 262763.)

Statement regarding approval

This project has received ethical approval from the University of Tasmania Human Research Ethics Committee.

Results of investigation

The results of the study will be written up for submission as a PhD research thesis. This will be made available upon completion on the World-Wide-Web.

6.6 Example of a MIKSIKE worksheet

From URL: <http://www.miksike.com/space/space9.htm> on 19th November 2000, reproduced with permission of Miksike Corporation.

INTERESTING FACTS ABOUT THE INNER PLANETS

Jasper read in a book that the planet Venus is beautiful to look at from a distance, but its atmosphere is very dangerous to us, and therefore exciting. For a moment he changed his mind and forgot planet X.

"Listen," he asked the Doctor. "Before we start on the more serious work, could we have a bit of fun with some interesting planets? I mean, you have so much material here, that we could find out something about planets too. Both scientific and interesting."

What objections could the Doctor have to that. "Tinker away and write down everything interesting that you can find about each planet. And at the end decide which planet you think is the most exciting."

The boys wrote. About each planet they wrote something which was unique which the others didn't have, or else much less of .. or the opposite.

MERCURY

Mercury has the greatest variation in temperature. Temperatures vary between -200 and +430 C.

.....



VENUS

1. In terms of its mass and size, Venus is the most similar planet to Earth.

- 2.
- 3.



EARTH

- 1.
- 2.
- 3.



6.7 Instruments for measuring ICT integration and results of meta-studies

Table 17: Some ways of measuring ICT integration in schools (USA).

Reference	Instrument	Strands, attributes, or components measured using the instrument	
Lemke & Coughlin, 1998 Milken Family Foundation	Seven Dimensions for Gauging Progress of Technology in the Schools	learners learning environments professional competency system capacity	community connections technology capacity accountability
Jones, Valdez, Nowakowski & Rasmussen, 1995 North Central Regional Educational Laboratory (NCREL)	Plugging In: choosing and using educational technology	Engaged Learning: vision of learning tasks assessment instructional model learning context grouping teacher roles student roles	High Technology: access operability organisation engagability ease of use functionality
Edmin.com, 1998	Maturity Model Benchmarks Survey ver. 2.5	administrative curricular support	connectivity innovation
National Study of School Evaluation, 1998	Technology: Indicators of Quality Information Technology Systems in K-12 Schools	Student Learning: information technology basics application and integration of technology use of creativity tools technology in life and society School Instructional Capacity: curriculum development instructional strategies and learning activities assessment of student learning	School Organisation: leadership, vision and planning professional development policies resources creating a community of learners
Bender, 2000	Measuring Technology Integration in Learning Environments	Teacher Response Instrument Teacher's beliefs and intentions regarding technology use and creating an environment for learning	The Classroom Observation instrument consists of 21 indicators. Nineteen of these indicators are rated 0–3.the last two are Technology Used and Software Used which are simply lists of the items observed in use during the lesson.

(Bingham, 2000)

Table 18: Meta-analyses of ICT in education (Sinko & Lehtinen, 1999)

Meta-Study	Studies analysed	Conclusions (Positive effect sizes indicate computers were found to enhance learning)
Ryan, A. W. (1991) Meta-analysis of achievement effects of microcomputers applications in elementary schools. <i>Educational Administration Quarterly</i> , 27(2), 161-184.	40	<p>The average effect size was 0.31.</p> <p>The computer software used was classified into these categories:</p> <ul style="list-style-type: none"> • drill and practice programs • tutorials • simulation • programming language • discovery programs • utilities <p>A combination of different forms of use was generally more effective than using computers in only one way.</p>
Kulik, C-L. C. & Kulik J. A. (1991) Effectiveness of computer-based instruction. An updated analysis. <i>Computers in Human Behavior</i> , 7, 75-94.	199	<p>This study also showed that cognitive achievement was improved by computer-aided instruction (effect size 0.30) . Later, Kulik (1994) published a summary of 12 previous meta-analyses, which turned out to have parallel results. The effect sizes found in these summaries reached all the way up to 0.50. Such large effect sizes already signify essential improvements in learning outcomes. (p. 37).</p>
Liao, Y. C. & Bright, G. W. (1991) Effects of computer programming on cognitive outcomes: A meta-analysis. <i>Journal of Educational Computing Research</i> , 7 (3), 251-268.	65	<p>Experimenters usually obtained higher effect sizes in short experiments and with computer environments which emphasise self-directed learning. (p. 38)</p>
Khaili, A. & Shashaani, L. (1994) The effectiveness of computer applications: a meta-analysis. <i>Journal of Research on Computing in Education</i> , 27, 48-61.	36	<p>The mean effect size ... was 0.38. Found evidence of Hawthorne effects (the novelty wears off after a while) and group size effects (smaller groups got larger positive effects).</p>
Fletcher-Flinn, C. M. & Gravatt, B. (1995) The Efficacy of Computer-Assisted Instruction (CAI): A Meta-Analysis. <i>Journal of Educational Computing Research</i> , 12, 19-242.	120	<p>For the various subjects, the greatest effectiveness was obtained in the teaching of mathematics.</p>

Table 18 (continued)

Meta-Study	Studies analysed	Conclusions
Cotton, K. (1997) <i>Computer-assisted instruction</i> . Portland, OR: Northwest Regional Educational Laboratory. School Improvement Research Series.	100	<p>The use of computers and word-processing software led to superior writing performance than traditional pencil-and-paper work, as manifested by longer written samples, greater variety of word usage, more variety of sentence structures, more substantial revision, greater responsiveness to teacher and peer feedback, better understanding of the writing process and better attitudes towards writing.</p> <p>The use of computers in teaching also led to positive changes in attitudes towards school and learning in general, as well as in motivation.</p> <p>The studies showed that using computers in instruction yielded different results for different student populations: low achievers and handicapped students benefited more than higher-achieving students; positive effects were greater with young students than with older ones; students with a weak socio-economic background benefited more than students whose parents were wealthy and highly educated; boys benefited more from computer-aided instruction than girls.</p> <p>The positive effects of computer-aided drill and practice programs were especially visible with respect to simple cognitive tasks such as retaining learned material and doing various routine tasks. (p. 35-36)</p>
Liao, Y-K. (1998) Effects of hypermedia versus traditional instruction on student's achievement. <i>Proceedings, annual meeting of American Educational Research Association, San Diego, CA.</i>	35	In most cases hypermedia environments produced better learning outcomes than traditional instruction. ...The mean effect size was 0.48
Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M. & Muukkonen, H. (1998) <i>Computer supported collaborative learning: A review of research and development</i> . CL-Net. A report for the European Commission.	200	Where computers were formerly viewed as a tool for individualising instruction, they are now viewed more and more as a tool for social interaction and collaborative activities. Many studies report positive learning effects with computer-supported collaborative learning. (p. 44)

6.8 Estonia background information

Figure 26: Europe – political: showing location of Estonia



(courtesy Perry-Castañeda Library Map Collection)

Figure 27: Estonia, showing towns visited during the research



(courtesy Perry-Castañeda Library Map Collection)

Estonia is a Baltic state in Europe, just south of Finland. In 1989, during the chaos following the attempted murder of the Russian premier, Mikahel Gorbechov, the Estonian people conducted a singing revolution. At some points as many as one in three Estonians were singing across the country in protest at the Russian occupation. On 6th September 1991, full independence was declared.

Figure 28: Singing Grounds in Tartu, Estonia.



The population decline in Estonia was significant, resulting from increased uncertainty as the country moved from deterministic soviet communist policies to engagement with global competitive market economics. The country often experiences winters so cold that the sea freezes, allowing ice roads to the outlying islands to be constructed. Trade patterns with the Soviet east have rapidly declined, and new partnerships have been forged with western European countries. As part of the enlargement of the European Community, the PHARE⁴ program allocates grants to aspirant nations (European Communities, 2000). Estonia has applied for membership of the European Union, and is being funded as an aspirant nation through the PHARE program to improve several aspects of its economy.

⁴ originally an acronym from 'Poland and Hungary: Action for the Restructuring of the Economy'

During the harmonisation of two economies, and many cultures, it is obvious that there will be agreement on many things, but not on all. For example, the Estonian perception of wolves was at variance with that of the European Community (EC)⁵. Yet PHARE-inspired social developments with information technology fitted well with the Estonian Information Policy (Estonian Informatics Centre, 1997). This established a need for projects in schools to make the younger generation familiar with and confident in the use of information technology, such as the “Tiger Leap” program. The original policy documents integrated information policy with other public policies, and showed how societal values might be shaped by the adoption of strategies of openness and geographic independence. By pointing out that an information society was not as bound to “place” as those preceding it, the policy aimed to establish a non-sectarian and location-independent way of looking at the situation of every citizen. The information policy was therefore considered to be a support for democracy in Estonia, and established a rationale for the development of an adequate information infrastructure. This author noted the high incidence of mobile phones whilst visiting the country, a telecommunications facility that had proven effective and easy to implement with 502,000 subscribers (one third of the population) in December 2001 according to Vasilyeva (2002). As the policy evolved, direction of the information policy was handed to the State Chancellery, which was given a coordinating role.

The multi-cultural background of Estonia was addressed by the information policy, which stressed the equal and open access citizens should have to government information. Languages of government had swept with invaders through Estonia throughout the twentieth century. In 1999 the phonebooks summarised contents in German, Russian and English as well as Estonian. While English was acquiring prominence as a supplemental language, for most people it was only a third language (after German or Swedish) learned in school, making access to much externally sourced software problematic for young people. This multi-lingual situation persisted because of the incorporation of non-native Estonian speakers into the population, such

⁵ Whilst the EU was legislating to preserve species of wolf which were disappearing from Nordic Countries, Estonia was plagued with many more than were considered safe.

as native Russian speakers who were principally responsible for operating shale oil electricity plants and mining operations predominantly around the area of Narva.

One of the impressive details of the Estonian experience with ICT in education has been its brevity. Following Estonia's unilateral declaration of independence in 1991, the forestry-financed government adopted a wide range of strategies to aspire to membership of the European Union as quickly as possible. There were some significant achievements. "For example, it is remarkable to note that there are more Internet hosts in Estonia than in sub-Saharan Africa (excluding South Africa)" (Mosco, 1998). A 1999 survey showed Estonia had 18 Internet hosts per 1000 head of population, compared to 148 for USA, and 49 for Australia (Department of Industry, Science and Resources, 2000, p. 23). This made Estonia 19th in the world on this measure. The country exemplified one extreme of the spectrum described by Hobbes in the Internet Survey (Zakon, 1999).

Teachers' wages had not risen with the increase in prosperity and consequently it was almost impossible to recruit or train teachers. One program brought retired teachers back into schools to fill the gap between supply and demand. Therefore, it was extremely difficult to introduce changes in practices or curriculum, particularly since the latter was very much bound to an established model which allocated a certain percentage of teaching time to each conventional subject area.

As an indicator of the stresses upon the country, the net population was falling in 1999. Births in 1995-99 were below natural replacement, and emigration exceeded immigration. With the removal of state security from the communist regime, parents deferred child rearing until their personal economics became more secure. One of the teachers this researcher talked to admitted that Estonians were not very social; a little house in the country, away from neighbours, was a common ideal.

Figure 29: Estonian house in the country.



Several of the outcomes of the PHARE project related to the development of cross-curriculum frameworks for the use of computers in schools. However, the current funding provided through the Tiger Leap project made the ratio of students to computers only 28 to one in the best situation seen. The project director argued that with such small levels of equipment, it had been impossible to mount whole school programs, and therefore they were unable to pilot such frameworks.

6.8.1 Project Tiger Leap

Project Tiger Leap hit the headlines during the summer of 1999, when it arranged road-shows in several major towns. Setting up tens or even hundreds of computers in tented accommodation in town squares, the project brought ICT to the people, signing many up for e-mail accounts, and demonstrating the powers of the new technology. That year the Tiger Leap Roadshow was the winner of the Global Bangemann Challenge Grand Prix in the category "Equal Access to Networking" (City of Stockholm Economic Development Agency, 2001).

Figure 30: Tiger Leap Roadshow in action, 1999.



With a broad remit to raise awareness of ICT in the community, the project had specific aims to also assist educational institutions. One of the products of this project was a bilingual multi-media introduction to the vertebrates of Estonia, prepared in hyper-text format and distributed both via the world-wide-web and a limited edition CD-ROM.

Figure 31: Introduction to vertebrates of Estonia



6.8.1.1 Professional development within Project Tiger Leap

A prime mover in the domain of awareness-raising and teacher development has been Project Tiger Leap. This project was funded internally within Estonia, and its strategy spelled out in the policy papers produced by the project (Tiger Leap Project, 1999). Between 1997 and 1999, policy implementation shifted from projects targeted upon areas of agreed need to one based upon submissions from teachers. One of the goals was to achieve a student:computer ratio of 20:1, and this was nearly achieved by the end of 1998 in 11 of the 18 Estonian counties, with an overall average of 28. Other infrastructure projects placed projectors into schools, enabled teachers to lease a computer for use at home, and established the web-based teaching materials MIKSIKE site. This was a joint winner of the Education section of the Stockholm Challenge in 2000. This was a transformative project, bringing about radical change in teaching practices. The project was described as follows:

The Miksike Learning Environment gives away more than 20,000 worksheets in HTML-called eWorksheets and offers a set of virtual teacher assistant (miksilitators) services, which are based on using these materials and other collaborative learning services.
(City of Stockholm Economic Development Agency, 2000).

The MIKSIKE learning environment expanded in 2000 to include materials written in Estonian, Russian, Swedish and English. The materials were available on the Internet for free, and encompassed over 20,000 worksheets for school students in K-12, and homeschoolers. These eWorksheets supported advanced study in isolated schools as well as a wide range of the traditional curriculum. One of the worksheets is reproduced as an Appendix 6.6 (Miksike, 2000).

Internet connections were provided for rural schools, and a large amount of money was allocated to the purchase and evaluation of educational software. Training for teachers and school network administrators was also provided, and over 56 percent of all teachers had completed an introductory course by the end of 1998. (Tiger Leap Foundation, 1998).

Within the sphere of professional development, the country has adopted the European Computer Driving Licence as the desirable qualification (Computing, 1998). This was

also offered in Australia as the International Computer Driving Licence, and comprised the following modules:

- Basic concepts of information technology
- Using the computer and managing files
- Word Processing
- Spreadsheets
- Databases/Filing Systems
- Presentation and Drawing
- Information Network Services.

The first module is assessed using a theory test, while the remainder are assessed practically (Australian Computer Society, 1999).

Key applications for translation between languages were unfamiliar to the project leaders the author interviewed in November 1999. It is likely that some version of automatic translation software for filtering externally hosted web-pages may improve access to the Internet in Estonia.

6.8.2 Curriculum development

The official Estonian curriculum for primary and secondary schools listed 13 major objectives in 1999. The eleventh one of these required that “pupils can get and use information”. It was used by the schools visited by this writer to justify the inclusion of computers in their learning programs. In the documentation supplied, the section describing the links between different subjects includes informatics and information technology as one of four such cross-curriculum areas, with legitimation important in a curriculum structure established during soviet occupation times. The organising principles appeared to revolve around the number of hours per week each subject was allocated, and what material should be covered in that time. Consequently, teachers have found it difficult to amend the curriculum in terms of content or time allocation to accommodate new initiatives such as ICT. Therefore, opportunities to do so have been taken in some less likely areas, such as Nature Studies, which had as a major study topic “the development of communication and study design skills”.

There had been some success in the secondary curriculum area, where Informatics was established as an area of specialist study for pupils aged 15-18.

Table 19: Secondary school informatics curriculum in Estonia.

Valikkursused gymnaasiumile	Subjects for secondary schools
INFORMAATIKA	INFORMATICS
Universaalsed pohitoed. Tekstitootlus	Universal applications: word-processing
Arvuti kasutamine andmete haldamisel	Databases
Arvuti kasutamine tookeskkonna muutmiseks	The changing work environment
Informaatika lisateadmised	Other informatics topics

The main focus for curriculum development with respect to the use of computers in education appeared to primarily be the responsibility of the program (Phare-ISE, 2000). This strategic plan included a role for the evaluation of ICT integration techniques and for the determination of a future policy strategy. Members of the program said that the best they could do was make recommendations, and the Ministry of Education alone had the power to enact change. Although the program had been in operation for two years when the researcher visited in 1999, the fourth work program schedule envisaged that development of policy in this respect would still be ongoing in 2000 (Phare-ISE, 2000b).

6.8.3 The PHARE-ISE program

Figure 32: Logo of the PHARE-ISE program



The PHARE-ISE project contracted through tender in July 1999 for the supply of a schools software management system. This student database program was to be

customised to Estonian language and conditions, and used to improve data flow between the Ministry of Education and schools.

One of the outputs of the PHARE-ISE program had been a sequence of three CD-ROMs. These had been very influential within the country, both to spread new techniques and information, but also as an awareness-raising exercise for the work the project was undertaking. Some of the material was in English, which enabled the researcher to assess the contents.

Table 20: Contents of PHARE-ISE CD-ROMs

Category	Examples of content
Freeware, shareware, public domain and demonstration software	<ul style="list-style-type: none"> • Linux • Logo • WordPad • Periodic Table etc.
Project products - curriculum software in Estonian Language	<ul style="list-style-type: none"> • Molecular modelling • Geometry • Probability theory for 12th grade etc.
Project - products	<ul style="list-style-type: none"> • Estonian spelling checker for Microsoft Word • StudyWorks etc.
Documentation - project program	<ul style="list-style-type: none"> • for PHARE-ISE and Tiger Leap projects • Contact lists of schools • Details of sub-projects underway • Minutes of steering committee meetings.
Documentation - other	<ul style="list-style-type: none"> • Estonian help files for Linux • Curriculum documentation • Syllabuses • Papers by academics and forward-looking teachers on the impact of ICT • Software reviews • Handbook of Estonian language

6.8.4 Summary

Estonia has focused upon development of the internet since independence, stimulated by the needs of a dispersed population in difficult terrain (especially in winter). Educational policies for ICT are highly aligned with national policies. Professional development has been provided so that 56 percent of teachers have ICT skills commensurate with the level of the international computer driving licence. The social rationale is an emphasis with ICT seen as offering services equitably to both rural and urban citizens.

6.8.5 Estonian Policy documentation – teacher ICT skills specifications

Requirements to the competence of educational technology of the comprehensive school teacher

Approved on 28. February, 2001 in the council of Informatics.

The necessity to specify the teachers' standards of competence of ICT:

The fast development of information and communication technology and its application in different fields of life influences our society, culture and most of all - our working environment and communication. Banking, logistics, mass media and science are only a few examples of the areas that have done through huge changes after the computers and Internet have been started to use. It is natural that school has to move along with all these changes as the main aim of it is to prepare the next generation to live in the world that will be even more technological. The current state curriculum of comprehensive school assigns to give the students the ICT competence through the other subjects, through an integrative theme. So it is presumable that teachers are able to use up-to-date methods and equipment not worse than for example, secretaries or book keepers.

The infotechnological development plan for the Estonian school, Tiger Leap Plus (Tiigrihupe Pluss), accepted by the Government of the Estonian Republic at the beginning of 2001, lays stress on teachers' infotechnological competence noting that as one of its priorities. It assumes an agreement about unitary demands on the competence. A lot of work has been done in the field of ICT professional standards, internationally acknowledged The International Computer Driving Licence (ICDL) certification system has been applied. At the same time it has become clear that ICDL will not be enough for teachers - the standards of ICDL have been oriented to an average office worker, they are not sufficient and they are out of context. What we need is a wider (considering the context of teaching situation) and deeper (at least three different levels) standard. Due to the context of teaching situations this cannot be the standard of computer competence only, but rather of the competence of educational technology. Educational technology is an area of pedagogy the aim of which is to develop, apply and evaluate the systems, methods and means created to support the learning process. Also the first international standards that evaluate the teachers' ICT competence are not oriented on computer competence only (NETS for Teachers, <http://cnets.iste.org>).

The following is our vision about the standard of the teachers' competence of educational technology, the applicable output of which is updating the curriculum of teacher training and completing the requirements of teachers' qualification. In the requirements of teachers' qualification, the computer competence has been mentioned as one of the qualification criteria. In the informatics council they specified the essence of this competence through the following. The teacher who likes to raise or preserve his professional qualification

- understands the essence of ICT hard- and software systems and is able to describe the principles of their working
- is able to use ICT hard- and software, if necessary - using help-system or manual
- knows the principles and methods of ICT-based active- and project learning
- on the computer creates instruction for students' independent work
- is able to find extra materials for his students in Internet and other electronic sources
- evaluates info/resources/materials critically, compares alternatives and refers correctly
- collects data and systemizes them with the support of ICT
- uses different means of ICT to form and present his works
- describes the role of ICT in the modern society, understands the role of ICT in the dynamics of labour market and his professional development
- is aware of-the juridical norms and rules connected with distributing and using ICT and behaves according to them
- is aware of the-dangers of using ICT-to his and his students' health,-social and mental development
- uses e-mail communicating with students, parents and colleagues.

6.8.6 Estonian Policy documentation – student ICT skills specifications from the national Department of Education.

**Chapter 3.
Information technology and
teaching media
Part 1. Information technology**

§ 351. Information technology as a passing subject

(1) Developing the competence of information technology in the comprehensive school is not connected with any concrete platform of hard- or software, producing company or set of software.

§ 352. The Aims of Learning

The aims of teaching *information technology* as a passing subject are:

- 1) The student understands the economic, social and ethical aspects connected with using information technology;
- 2) The student masters the skills of using information technology independently. omandab infotehnoloogivahendite iseseisva kasutamise oskused [sic].

§ 353. The School-leavers' Competence by the End of Comprehensive School and Gymnasium

The school-leaver:

- 1) uses effectively and skillfully the input devices of the computer (mouse, keyboard), output devices (printer, monitor) and the memory devices (diskette, CD-ROM, hard drive);
- 2) knows how to use the graphical interface of the operation system;
- 3) knows how to use the local network and administer the document files;

- 4) can use the correct terminology in his mother tongue when speaking about information technology, can describe the simpler problems connected with hard- and software;
- 5) behaves ethically and correctly when using information technology, is aware of the consequences of misuse information technology;
- 6) handles the hard- and software with responsibility and economically;
- 7) can describe the role of information technology in the society and the importance of that from the aspect of choice of vocation;
- 8) is able to plan, create and present interesting texts, multimedia presentations, advertisements etc that have been made independently or in co-operation with classmates using information technology;
- 9) uses information technology effectively to find information and to communicate on academic aims, chooses the best way to solve the problem or task;
- 10) understands the necessity of critical evaluation of the Internet resources (is it correct, appropriate, sufficient and objective);
- 11) can manage with easier statistical analysis with information technology (frequency, average, diagrams).

6.9 USA background information

6.9.1 National policy

The essence of American education is characterised by the decentralisation of its system and the allowance for diversity in instructional practice (Anderson, 1996, p. 445)

The USA shows extreme examples of uniformity (all classes have between 19 and 27 students) and disparity (some States spend up to three times more per pupil than others) (Anderson, 1996, p. 445). Ten percent of students go to non-public schools, and boards of the 15,000 local school districts make policy for the remainder in public schools. These boards are mainly democratically elected rather than appointed, and largely independent of State control (Barham, Coyle, & Garrou, 2002, p. 23).

Anderson (1996, pp. 460-462) reported four curriculum models for the use of computers in schools, although he said “it would be questionable to suggest that the United States has a computer curriculum” at that time. The four models he observed were:

- Programming or problem solving
- Computer literacy
- Computer as tool
- Technology integration.

As with any innovation issue, the stresses and strains in the normal administrative framework are exacerbated for decision-makers by new principles and personal unfamiliarity with information technology. Therefore some imaginative ways of introducing computers into schools have been adopted in the US as well as other countries. One such scheme has been to recycle obsolete computers from business or government into schools, which has also been done in Australia (Tasmanian Department of Premier and Cabinet, 1999). In the case of computers which have had their hard-drive wiped for security or commercial confidentiality reasons before this transaction, operating system and educational software has to be alternatively sourced to make them operational again. Diane Frank describes Federal government assistance to shore up this breach as an example of maximising the benefits of public monies

(Frank, 1998). The 1998 national data for the USA indicated there was a student-computer ratio of about six public school students per computer, with variations favouring small schools in rural locations (US Department of Education, 2000).

The US Census Bureau reported that 49.7 percent of school students had home access to computers in 1997, with children over the age of 12 having greater access. Use and access depended to a great degree upon parental income and educational achievement. More children used a computer at school than at home, though no analysis was provided of the duration for either setting. Games had given way to educational activities as the most frequent home computer use between 1993 and the 1997 surveys. One fifth of children with a computer at home also had Internet access (Newburger, 1999).

An important point in national policy was reached on 23rd January 1996, when President Clinton included in his “State of the Union” address the call for every classroom to be connected to the Internet (the ‘information superhighway’). This was followed on 15th February 1996 by the launch of the Technology Literacy Challenge, and shortly thereafter, in June 1996, the nation’s first national educational technology plan, *Getting America’s Students Ready for the 21st Century: Meeting the Technology Literacy Challenge* (Office of Educational Technology, 1996). This plan was under review at the time of writing, with the year-long revision due to be completed by the northern hemisphere Autumn (approximately November 2000). Some of the products of this process are discussed at the end of the chapter.

6.9.2 The significance of national strategies

At the APEC Workshop in Canada (3-6 December 1999) the delegate from the United States Education Department revealed that the Federal government has traditionally been able to affect only a small part of the public education process. This was because its contribution to funding amounts to only about six percent of the total. The supporting data for this assertion were later posted on the web-site reporting the Workshop as shown in Table 21.

Table 21: Education funding in the USA by level of government (1998)

Source of funds by government level	Billions of dollars	Percent
Federal	\$22.6	6.1
State	\$162.4	43.9
Local	\$147.5	39.0
All Other	\$36.6	10.2

(US Department of Education, 2000)

However, the delegate maintained that the total Federal funding for information technology in education amounted to 25 percent of the total spending for ICT in schools, illustrating the perceived need to facilitate rapid change. This funding at four times the normal level of support was directed into information technology by a variety of processes, including special education funding. This quadrupled proportion of resourcing for ICT allowed the Federal Government a much more significant role. White (1997) reports an analysis done by New York-based management firm McKinesey & Co. Inc. which stated that the remaining 75 percent for ICT in schools came from state governments (20 percent), local school districts (40 percent) and private sources (15 percent). This suggests that the extra funding provided by the Federal government has been required to compensate for deficiencies at the State legislature level.

Other examples of targeted grants from the Federal Government were seen in parts of the program *Preparing Tomorrow's Teachers to use Technology* (Department of Education, 1999). This program made over 200 grants in 1999, totalling US\$53,750,000, with 40 percent of those awards continuing for three years. The grants were available in three forms: capacity building, implementation and as catalyst grants for large-scale development or certification projects.

6.9.3 Curriculum development

The NETS (National Educational Technology Standards) Project was an initiative sponsored and run by ISTE (International Society for Technology in Education, 1998). The project flowed from the Society's involvement in national teacher

accreditation work, but was given a structure that went beyond this when funding appeared to be available from a variety of partners including Apple Computer Inc., The Milken Exchange on Education Technology, the National Aeronautics and Space Administration (NASA) and the US Department of Education. The overall shape of the project is given in Table 22.

Table 22: National Educational Technology Standards project plan

Standards for school implementation	standards for students	Cross-curriculum standards for enhancing student learning with technology
	connecting curriculum and technology	Providing curriculum provided examples of effective use of technology in teaching and learning.
	educational technology support standards	Projected to describe standards for professional development, systems, access, and support services essential to support effective use of technology
	standards for student assessment and evaluation of technology use	Projected to describe various means of assessing student progress and evaluating the use of technology in learning and teaching
Standards developed with NCATE (National Council for the Accreditation of Teacher Education)	pre-service standards	Standards for accreditation of teacher preparation programs for specialisation in educational computing and technology,
		Unit guidelines describing essential conditions needed to support technology use in teacher preparation programs
		General standards for providing a foundation in technology for all teachers

The Standards for students were particularly relevant to this study, and these are described in detail in Table 23. They provided evidence of a national impetus towards the Phase 2 outcomes proposed in the broad aims of this study. A judgement of these nationally produced standards could be used to make an assessment of the general level of expectations for information technology in school classroom.

Table 23: National Educational Technology Standards for Students

Basic operations and concepts	Students demonstrate a sound understanding of the nature and operation of technology systems. Students are proficient in the use of technology.
Social, ethical, and human issues	Students understand the ethical, cultural, and societal issues related to technology. Students practice responsible use of technology systems, information, and software. Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.
Technology productivity tools	Students use technology tools to enhance learning, increase productivity, and promote creativity. Students use productivity tools to collaborate in constructing technology-enhanced models, preparing publications, and producing other creative works.
Technology communications tools	Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences. Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
Technology research tools	Students use technology to locate, evaluate, and collect information from a variety of sources. Students use technology tools to process data and report results. Students evaluate and select new information resources and technological innovations based on the appropriateness to specific tasks.
Technology problem solving and decision-making tools	Students use technology resources for solving problems and making informed decisions. Students employ technology in the development of strategies for solving problems in the real world.

(International Society for Technology in Education, 1998)

These six areas for students aligned very well with other national frameworks of similar intention, with the main points of basic operational skills, a standard set of computer learning modes and a section on social impact. The last section was not found universally, although it was common in the curricula of other countries. There seemed to be some debate as to whether the impact of computers on society was a particular element of study within the ICT curriculum or whether it should be addressed in the general social issue areas of the school. As social studies staff might be untrained to include this relatively new area of concerns in their teaching, the

option of assigning them the task of teaching about the impact of computers might not be appropriate. However, this author has seen the issues covered in the context of a religious education program with a focus on harmonious living which embraced a gamut of social concerns from nuclear power to genetic engineering. Information technology was placed in a relative context alongside these other topics.

6.9.3.1 Texas

Most states of the USA have their own standards for the absorption of information technology (usually just referred to as ‘technology’) into school education. Texas has a set of objectives for learning in most curriculum areas called TEKS (Texas Essential Knowledge and Skills). A subset of these is called Technology Applications, and the exposition by the Texas Center for Educational Technology makes it clear that:

The Technology Applications TEKS strands are designed so that connections can be made easily with other content areas. It is important that the Technology Applications TEKS are connected with learning in other areas and not seen as isolated knowledge and skills.

(Texas Center for Educational Technology, 1999)

Within this scheme, presented in the legislation as a separate course, but with this cross-layering intention, there are four main strands, as shown in Table 24.

Table 24: Texas TEKS technology applications strands (1999)

Foundations:	Through the study of Technology Applications foundations, including technology-related terms, concepts, and data input strategies, students learn to make informed decisions about technologies and their applications.
Information Acquisition:	The efficient acquisition of information includes the identification of task requirements; the plan for using search strategies; and the use of technology to access, analyse, and evaluate the acquired information.
Solving Problems:	By using technology as a tool that supports the work of individuals and groups in solving problems, students will select the technology appropriate for the task, synthesise knowledge, create a solution, and evaluate the results.
Communication:	Students communicate information in different formats and to diverse audiences. A variety of technologies will be used. Students will analyse and evaluate the results.

In reporting the reaction of pre-service educators to these technology applications TEKS, Salinas (2000) found them keen to integrate this issue with others they had been exposed to. As one student teacher expressed it: “So important are the multi-intelligence activities and responding to the needs with multiple intelligences. I think technology can help us to address those needs”. This feeling that technology can and will provide an extra dimension to teaching, and an ability to cope with a multiplicity of learning needs in a single classroom can be common for supporters of IT. It may have some justification in fact, for as Cuban (1999) asserted, many studies have shown “computer-assisted instruction does increase test scores, particularly if its aimed at reading and math and certain levels of skills”.

6.9.3.2 Ohio

The Ohio SchoolNet Learner Technology Profiles were modelled fairly strictly on the ISTE National Educational Technology Standards for Students (see Table 25).

Table 25: Ohio SchoolNet Learner Technology profiles

Basic operations and concepts
Social, ethical, and human issues
Technology productivity tools
Technology communications tools
Technology research tools
Technology Problem Solving and decision-making tools

(Ohio SchoolNet, 1999)

Having established the profiles for students, the organisation went on to produce a learning matrix for teachers which closely follows them. This high degree of alignment between curriculum intentions for students and training outcomes for teachers is a notable feature of this set of policies. Both sets of outcomes also align strongly with the ISTE/NETS standards, and this has been identified in Table 26.

Table 26: Paraphrase of the Ohio SchoolNet technology learning matrix for teachers

	Productivity	Information	Network	Hypermedia
Novice	word-processing	CD-ROMs	video-conferencing	traditional teaching
Practitioner	spreadsheet	e-mail	groupware	multi-media presentations
Scholar	databases	searching and collaboration	teaching resources from Internet	policy formulation, electronic resource recommendation
Expert	project planning, desktop publishing	e-group management, software evaluation	problem solving	development of digital teaching materials
<i>Commentary</i>				
<i>Aligns with ISTE/NETS</i>	<i>Basic operations and concepts & Technology productivity tools</i>	<i>Technology communications tools & Technology research tools</i>	<i>Technology research tools & Technology Problem Solving and decision-making tools</i>	<i>Integrates other skills into a framework to facilitate teaching and learning.</i>

(Ohio SchoolNet, 1999)

It is clear from this example that even in a large federated country such as the USA, the constituent autonomous regions can quickly adopt nationally established standards. The mechanism by which this adoption can take place varies, but in the case of the USA, targeted central funding, tied to the adoption of nationally agreed standards, has been quite effective. Whether or not these standards represent the ideal level of attainment is another question, which was examined by some of the professionals interviewed in the study.

6.9.4 Teacher training and professional development

In 1999 there were 1248 schools, colleges and departments of education providing teacher education. In the US the National Council for the Accreditation of Teacher Education (NCATE) accredited many of these through a voluntary process, although state accreditation is generally mandatory. These institutions were surveyed to find how they were preparing new teachers to use information technology in their work (Moursund & Bielefeldt, 1999). The survey analysis revealed four reasonably discrete factors: facilities, integration, application skills and field experience. About one-third

of the surveyed sample felt their programs were limited because of deficiencies in their IT facilities. This meant that staff could not adequately model skills (which both they and students possessed), leading to lower integration of IT use into courses. However, the best predictor of integration was basic technology proficiency, as represented by scores in the application factor.

The authors of the survey recommended that IT instruction be integrated into other courses, and that faculty staff should be rewarded and motivated to do this, once sufficient IT infrastructure capacity was available. An area of concern was the lack of opportunity for students to practice IT integration skills in the field under the supervision of competent staff, and this would perhaps require external changes before it could be fully resolved.

The survey made no recommendations relating to the significance of application skills in determining integration, except to suggest that mature-age entrants to teacher education programs be offered stand-alone IT skills courses to give them the same level of expertise found in recent school-leavers. A more methodical approach might be to assess all entrants to the course for technology-specific and local ICT infrastructure-specific skills, and to remediate these when found deficient. It was thought possible that technology update training might be required for all students during the course, since technical advances are proceeding so rapidly that initial skills would become obsolete during a 4-year teacher education course.

ISTE was involved in devising ICT standards for pre-service teacher education with the Foundation Standards reflecting professional studies in education that provide fundamental concepts and skills for applying information technology in educational settings. It was recommended that all candidates seeking initial certification or endorsements in teacher preparation programs should have opportunities to meet the educational technology foundations standards. These NCATE standards for teachers are listed in Table 27:

Table 27: NCATE-approved standards in technology for all teacher trainees

<p>A. Basic Computer/Technology Operations and Concepts. Candidates will use computer systems-run software to access, generate and manipulate data, and to publish results. They will also evaluate performance of hardware and software components of computer systems and apply basic troubleshooting strategies as needed.</p>	1. operate a multimedia computer system with related peripheral devices to successfully install and use a variety of software packages.
	2. use terminology related to computers and technology appropriately in written and oral communications.
	3. describe and implement basic troubleshooting techniques for multimedia computer systems with related peripheral devices.
	4. use imaging devices such as scanners, digital cameras, and/or video cameras with computer systems and software.
	5. demonstrate knowledge of uses of computers and technology in business, industry, and society.
<p>B. Personal and Professional Use of Technology. Candidates will apply tools for enhancing their own professional growth and productivity. They will use technology in communicating, collaborating, conducting research and solving problems. In addition, they will plan and participate in activities that encourage lifelong learning and will promote equitable, ethical and legal use of computer/technology resources.</p>	1. use productivity tools for word processing, database management and spreadsheet applications.
	2. apply productivity tools for creating multimedia presentations.
	3. use computer-based technologies including telecommunications to access information and enhance personal and professional productivity.
	4. use computers to support problem solving, data collection, information management, communications, presentations and decision making.
	5. demonstrate awareness of resources for adaptive assistive devices for student with special needs.
	6. demonstrate knowledge of equity, ethics, legal and human issues concerning use of computers and technology.
	7. identify computer and related technology resources for facilitating lifelong learning and emerging roles of the learner and the educator.
	8. observe demonstrations or uses of broadcast instruction, audio/video conferencing and other distance learning applications.
<p>C. Application of Technology in Instruction. Candidates will apply computers and related technologies to support instruction in their grade level and subject areas. They must plan and deliver instructional units that integrate a variety of software, applications and learning tools. Lessons developed must reflect effective grouping and assessment strategies for diverse populations.</p>	1. explore, evaluate and use computer/technology resources including applications, tools, educational software and associated documentation.
	2. describe current instructional principles, research, and appropriate assessment practices as related to the use of computers and technology resources in the curriculum.
	3. design, deliver and assess student learning activities that integrate computers/technology for a variety of student group strategies and for diverse student populations.
	4. design student learning activities that foster equitable, ethical, and legal use of technology by students.
	5. practice responsible, ethical and legal use of technology, information and software resources.

(International Society for Technology in Education, 1996)

6.9.5 School programs

The development of programs in schools was dependent upon both local needs and national or state directives. These needs did not lie solely in the direction of educational advancement, and some inventive ways were devised to both justify expenditure and to derive income. A particularly inventive program was reported in a group of ten Michigan middle schools that served needy inner city and rural school

areas. Informed by FBI (Federal Bureau of Investigation) data showing teenage school students were at most risk of committing violent acts and being victims between 3 and 6pm, after-school community care centres were equipped with computer clubhouses. The program has seen the emergence of a unique youth culture based on ideas of freedom to learn, respect for one another, and a healthy attitude toward cooperative learning and shared knowledge⁶. The project focused on language arts, social studies, science and mathematics, and aimed to help improve communication and critical thinking skills (Girod & Zhao, 2000).

The 1965 *Elementary and Secondary Education Act* was reauthorised in 1994, becoming the *Improving America's Schools Act*. This included Title III, Technology for Education, which in turn included the *Technology Literacy Challenge Fund (TLCF)*. Congress found fifteen reasons for focusing on technology for education, and allowed local flexibility in implementation. Integrated with the national technology plan, the program had four main pillars (United States Department of Education, Office of Elementary and Secondary Education, 1999, p. 4):

All teachers in the nation will have the training and support they need to help all students learn through computers and through the information highway;

All teachers and students will have access to modern multi-media computers in their classrooms;

Every classroom will be connected to the Information Superhighway and

Effective and engaging software and on-line learning resources will be an integral part of every school's curriculum.

⁶ There can be no doubt that computers have become rapidly popular with students (Quinn, 1998). Theories of empowerment, neuro-biology (Fluck, 2000c), and motivation have been put forward to explain this. In some cases the popularity of computers has been so great that students have used them too much. The author was present at an interesting meeting of teaching staff at a college in Tasmania in 1992 when it was argued that e-mail should be banned from the computer network. Opponents of the facility were concerned that the universal student addiction to its use was detrimental to learning, for they preferred this use of computers to the on-task activities set. A rapprochement was reached whereby this casual use of the equipment was permitted for the first and last 5 minutes of 90 minute classes, and the imposition of a 15 minute internal delay on this facility prevented extended chat-type use.

The responses of States to this initiative were mixed. On one hand, the State of Oregon was granted exemptions and invested money into technology planning, a necessary pre-requisite for many other grant schemes available. Ohio combined TLCF funds with its own programs to invest in computer resources for schools, and created the SchoolNet professional development organisation. The report highlights this wide variation, and suggested steps be taken to at least co-ordinate evaluation of state progress on the four pillars.

6.9.6 Analysis

The 1999-2000 review of the USA's first national educational technology plan has produced some visions for the future (Office of Educational Technology, 1999). Roger Schank used the forum to challenge ideas that schools should persist in their current form:

Instead of teaching academic subjects, teachers and schools will focus on combating the increasing social isolation that our society will face. Schools will become activity centers where students work in groups on real-world projects, go on trips, and participate in the community. While students may also use schools as locations to engage in on-line course work, this course work will be just as available at home.

This indicates a movement towards a transformation of school education. In this national review forum, such a position could be considered to have significance for the likely direction the Federal government of the country concerned may take in the future.

In terms of preparation, an on-line survey by *Technology and Learning* magazine found that 72 percent of teacher education colleges reported a requirement for students to complete a technology course as part of general teacher certification programs (Proftak, 1999). This indicated a widespread understanding of the importance of the issues, but, without a breakdown of the content of such courses, it was not possible to say whether this represented a general transformation.

Some hesitancy was expressed in terms of equity issues when discussing the importance of home-based computers in learning. The question of the "digital divide"

was investigated by market research group Gartner (Smolenski, 2000). He concluded that access alone was an insufficient measure of this division within society, since some socio-economic groups had less experience in using the Internet, and used it for different purposes. This would seem to be a difficulty that would be overcome naturally as access increases to reach everyone in the country. Smolenski urged government to adopt policies that closed the divide, by encouraging business practices that maximised home access and use. Unusually, he suggested that students, not schools be targeted for Internet access, contrasting the relatively small amount (1 hour per week) young people were able to use it in school with the potential of home use.

Other hesitations were expressed by groups that questioned the validity of learning experiences through computers for particular groups of students, especially the very young (Cordes & Miller, 2000). While applying the technology inappropriately would be accepted as counter-productive, their other argument about the real cost of ICT in schools was a strong one. A full costing of periodic hardware updating and teacher professional development was expected to be nearly five percent of total school budgets. However, they also comment on a government report that recommended more use of technology, since “the probability that elementary and secondary education will prove to be the one information-based industry in which computer technology does not have a natural role is far too low to spend money on investigating the matter” (President’s Committee of Advisors on Science and Technology, 1997, p. 93-4).

These reservations about the use of computers mirror the messages coming from classroom teachers and educational administrators, making a potentially insuperable combination of difficulties for innovation. The background study of the USA had shown that these difficulties were being addressed in a piecemeal fashion, with small instances of development, and remarkably little information flow from layer to layer in the educational hierarchy.

6.10 England background information

6.10.1 National policy

In 1999 the government established some criteria for modernising its own processes through the application of information technology (Prime Minister and Minister for the Cabinet Office, 1999). In the initial phases of a long-term project, the intention was declared to apply the benefits of information technology to government. The two main benefits of this approach were the potential integration of government services and mechanisms to make it more responsive to the needs of citizens. The strategy was quite forthcoming about the first of these benefits, and a considerable amount of detail was released on how this would be useful. For instance, policies might be integrated irrespective of the originating government department, hopefully eliminating overlaps and working at cross-purposes. Examples were given of citizens being potentially able to inform all sections of government of a change of address in a single transaction, and to access government services 24 hours a day.

The detail on how government might become more responsive was less forthcoming. A general commitment to making policy formulation more sensitive and forward-looking merely re-iterated political speeches of the previous century. Whereas service delivery was to be improved through digital signatures, web-sites and call centres, the nearest application of similar new technologies in the matter of policy formulation was a 5,000 strong People's Panel, which would be sampled to forecast public reaction to proposed changes. A contrasting perspective of what might be possible was discussed by John Nieuwenhuizen (1998): "If the superhighway fulfils the expectations of its more ardent enthusiasts, we'll see an insidious drift away from representative democracy toward some form of what's called direct or participatory democracy." This open government initiative joined other proposals on e-government (Cabinet Office, 2000) and e-commerce (Allan, 2000) to give a fresh approach to the way in which information technology could change society.

The evolution of IT in schools represented a microcosm of the events in a range of social policy areas that had culminated in the initiatives described above. The history

of IT in the classroom went back much further, almost thirty years. IT initiatives for schools had come from more than one government department and in a succession of waves, each characterised by a fresh start, replacing previous programs almost as if they had never existed.

The Council for Educational Technology was constituted in 1967 to explore the application of computers in education. An “A” level in Computer Science was awarded in 1969, indicating the early acceptance of this subject as worthy and capable of study in school education. In 1981-83 the British Ministry of Trade and Industry sponsored the widespread introduction of computers into schools by offering a 50 percent subsidy on a limited variety of locally produced machines. This gave some concerns to the Department of Education, which belatedly initiated some plans for the training of teachers to use the new equipment, and to devise new learning strategies to accompany this. The philosophy of this first approach was described with chairman Mao Tse-Tung’s phrase, reiterated for the successor Teaching and Learning Technology Program in Higher Education: “let a thousand flowers bloom” (Turpin, 1997; Han, 1976). At the time, this seemed an appropriate strategy, because there was no clear evidence informing the nature of IT use in education. The Micro-Electronics Education Programme (MEP) established centres throughout England and Wales, with the Scottish Council for Educational Technology providing a similar program in Scotland.

As part of the on-going pressures to obtain money from the Treasury, the Department of Education commissioned the UK ImpacT study from 1989-91 (Watson, 1993). This study used a mixed methodology, with matched experimental groups in mini-studies, and subject reasoning assessments. The consolidated table of results showed only one combination where IT inhibited learning: in the subject-reasoning test for 8-10 year old pupils of Science (Johnson, 1995). In all other cases where there was a clear result, positive effects from the use of IT in the classroom were detected. This result substantiated continued government funding in the area.

The MEP was re-focused and re-organised under a succession of leaders over the following years, becoming the Micro-Electronics Education Support Unit (1986), the

National Council for Educational Technology (1988), and most recently, the British Educational Communications and Technology Agency (Becta, 2000). With these re-organisations, there was a move from the experimental and early adoption phases of the innovation diffusion process to a national development and support role for information technology in the national curriculum. This was introduced as a consequence of the Educational Reform Act of 1988 (Bergen, 1996, p. 429).

Following the transition to a Labour Party Government in 1997, much of the policy in respect of computers in schools was based upon the ‘Stevenson Report’. This was named after the chairman of a commission that investigated the situation for the Party prior to the election (The Independent ICT in Schools Commission, 1997). It set out the need for radical change in the education area in respect of ICT, and the new government soon implemented many of its proposals.

This change has seen developments on three fronts:

- Initial teacher accreditation (and related requirements for initial teacher training courses)
- Widespread impact on the 2000 revision of the National Curriculum
- Lottery-funded training courses for all in-service teachers.

These were spelled out in detail in Department for Education and Employment (DfEE) Circular 4/98, which had a host of annexes giving specific instructions for particular areas. Of note in the examination of these documents is the attempt to structure them to appeal to teachers, by emphasising the primacy of teaching and learning, and continually stressing the rationale for choosing ICT rather than some other methodology. This approach means that a generic analysis of the revised policy cannot be made on the surface of it, since each example is intended to be rooted in the subject matter of the pupil materials. However, there is a clear flow of generic intent from previous iterations of the policy process, and these were examined.

The launch of the National Grid for Learning (NGfL) in 1997 gave a clear indication that central government was serious about facilitating educational reform through the application of information technology (Selwyn, 1998). As Robert Girling commented

“there is a clear commitment to the concept that new technology is vital for educational and, therefore, economic success” (The Advisory Unit, 1998). In the same report, it was noted that the UK was unique among G7 countries, the leading seven industrial countries, in that it defined a student’s entitlement to ICT from ages five to sixteen across the curriculum. In comparison, other countries notably lacked provision for primary school children in their policies (The Advisory Unit, 1998, p. 5). By 1998, a majority of all schools reported through a national survey that ICT had improved the quality of teaching and had improved pupils' motivation to learn (Department for Education and Employment, UK, 1998b, p. 17).

A report on progress by the Teacher Training Agency (European Schoolnet Newsdesk, 2000) showed that very few primary and special schools taught ICT as a separate subject, preferring to teach it across the curriculum, mostly in English. However, secondary schools were teaching ICT generally as a separate subject, and also using it in Business Studies and Design and Technology. Virtually all schools had an ICT coordinator, with 2 hours per week non-teaching time allowed in most primary and special schools, and 4 hours per week in secondary schools.

6.10.2 Organisation of education

Increasingly the educational governance of England can be distinguished from the rest of Great Britain. Scotland has traditionally maintained its own education system, and Wales has recently become more assertive in this respect. Both the Welsh Office and the Scottish Office have implemented many of the programs that have originated in Whitehall, with local variations.

In making a judgement about the degree of devolution of policy control for education, the legal framework around the National Curriculum (1989 and subsequent revisions) needs to be examined. Funding and daily operation of the majority of English schools remains the responsibility of Local Education Authorities (largely based upon the Counties). However, core curriculum and educational standards, enforced by the Office for Standards in Education (OFSTED), are set and maintained centrally. In this respect, the English education system can be described as centralised, rather than devolved.

6.10.3 Curriculum development

The first national curriculum was introduced into England in 1989, revised in 1995, and another review was due for implementation in September 2000.

The place of IT in the UK national curriculum has undergone several transformations as it has been revised. The original 1990 version had information technology added as an extra attainment target for the subject area of design and technology (HMSO, 1990, p. 43). Students were to be taught how to:

- communicate and handle information
- design, develop, explore and evaluate models of real or imaginary situations
- measure and control physical variables and movement.

In the associated program of study, pupils were asked to “develop information technology capabilities through a range of curriculum activities” (p. 51), and IT was described as a cross-curricular skill which should be taught as an integral part of most foundation subjects in primary and secondary schools.

In the 1995 revision (Department for Education, 1995), Information Technology was separated out as a distinct subject, and pupils were given guidelines to use information technology for:

- learning technical skills
- communicating and handling information
- controlling, measuring and modelling.

Once again, this was to be done in a cross-curriculum context, with opportunities to develop and apply their IT capability in the study of National Curriculum subjects.

In the review for implementation in August 2000, the Secretary of State proposed to make the changes minimal, and encourage networking, particularly through the National Grid for Learning. With respect to computers in the curriculum, the term IT was replaced by ICT, and requirements were organised within four strands across all key stages. In this revision (Qualifications and Standards Authority, 1999) there were 13 subjects:

Table 28: Subjects in the National Curriculum for England (1988-2000)

Core subjects	English
	Mathematics
	Science
non-core Foundation subjects, with some age-variation in the mandatory nature of some subjects.	Design and Technology
	Information and Communication Technology *
	History
	Geography
	Modern foreign languages
	Art and Design
	Music
	Physical Education
	Citizenship *
Personal, Social, and Health Education	

* New subjects in 2000

ICT-based control, monitoring and measurement were moved into the Science and Technology subject programs of study, and other subject areas had specific ICT elements written into them (QCA, 1999). Information technology was identified as one of six key skills to be taught across the curriculum and, like the other key skills, was embedded into each of the other subject areas. ICT itself is described in terms of four strands, and a contextual descriptor:

Table 29: ICT in the UK 2000 National Curriculum

Strands	Context
finding things out; developing ideas and making things happen; exchanging and sharing information; reviewing, modifying and evaluating work as it progresses;	breadth of study, (which indicates the range of situations and subjects in which the knowledge skills and understanding can be studied).

ICT was also to be used to support learning in other subject areas, and this was to support the acquisition of ICT capabilities: “Pupils should be given opportunities to

apply and develop their ICT capability through the use of ICT tools to support their learning in all subjects” (p. 36).

In terms of curriculum development, the UK research establishing the efficacy of information technology in education has been quite thorough. For example, the British government was stimulated to fund three investigations into the veracity of mostly American claims that Independent Learning Systems (ILS) would revolutionise learning for all children. Such systems became capable of placing a huge amount of curriculum content on a single computer fileserver and delivering it on an individualised basis to pupils logged on to multi-media workstations on the same network. Examples of the capacity of such systems suggested they could provide a half-hour lesson in English, Mathematics and Science for every day of a child’s compulsory school education, and provide those lessons in up to 5 different forms to accommodate different learning styles. Costs of installation and annual licence fees were very high, increasing the perceived need for independent verification of the claimed effectiveness.

Professor David Wood (1998) summarised the three phases of enquiry. According to the Becta board they constituted the largest independent study of ILS in the world, and used a mixed set of projects to ensure the study was not confounded by methodological bias. Early results were quite encouraging, but pupil progress was neither universal nor uniform. In his summary, Professor Wood commented: “There is considerable evidence that pupils do learn from integrated learning systems. The main issue is not if pupils learn, but what and how they learn [his emphasis].” In the first phase of the study, students using ILS outperformed control group peers in mathematics, and these gains were sustained (albeit at a lower rate) in the second phase (Underwood, Cavendish & Lawson, 1994). In the third phase, gains were reported for Year 8 students, but not for Year 5 students.

In English, the results of the first two Phases were inconclusive, while in Phase 3 the Year 5 students showed negative gains from ILS, but the Year 8 students showed small positive gains compared to controls.

A significant result from the third phase of the study showed that students using the ILS did not make any additional progress on national examinations or tests. This was explained by the nature of the tests, which asked pupils to generalise material learned into new contexts, and it appeared that the ILS did not promote that kind of learning.

Overall, the studies concluded that students and staff were motivated by the ILS systems, but that technology management and how technology was used in the school were critical factors in their success, which corresponds with the general alignment of ICT and general school effectiveness. Teachers sometimes had difficulty understanding the output of the diagnostic and management systems of the ILS, and this was considered an area where software designers could improve the systems.

This sequence of investigations, and the kind of result manufacturers would rather not see, could explain the general attitude to the concept of independent learning in England at the time the interviews were conducted as a part of this current study.

6.10.4 Teacher accreditation

In 1999 the Teacher Training Agency published details of new requirements for candidates for Qualified Teacher Status. Starting with paper-based tests of numeracy to be passed in addition to the completion of a recognised initial teacher-training course, by 2001 there would be computer-based tests of numeracy, literacy and ICT for all (Teacher Training Agency, 1999). The requirements sprang from a government green consultation paper earlier in that year, which made proposals for teaching reform including extended pay-scales, performance management, a national college for school leadership and several other innovations.

However, before this, in 1998, the Department of Education and Employment had published new competency standards for initial teacher trainees. All student teachers were expected to meet a set of competences in ICT (Department for Education and Employment, UK, 1998, Annex B). These competences fell into two areas:

- Effective teaching and assessment methods
- Knowledge and understanding of, and competence with, ICT.

Initial teacher trainees were expected to investigate pupils' use of ICT within their school experience, and to submit a portfolio on the use of subject-based IT in school.

6.10.5 Teacher training and professional development

Following these developments, funding was secured from the New Opportunities fund of the National Lottery. This was to provide training for serving teachers to increase their expertise in the use of ICT in their subject teaching to the level expected of newly qualified teachers. The initiative was one of the most extensive ever undertaken in teacher-training. Funded with £230 million of National Lottery money, the training specifications were virtually identical to those for initial teacher training, based upon the same two areas of competency. Consistently stressed in the documentation was the need to ensure that teachers learned how to decide when, when not, and how to use ICT effectively in teaching particular subjects. It was also important that training be firmly rooted within the relevant subject and phase.

Tenders had been called for automated systems for testing the literacy, numeracies, and ICT competency of teacher graduates, and these became available in 2002 (online at <http://www.canteach.gov.uk/support/skillstests/benchmark/index.htm>). It was noted that the ICT test was strictly related to the operation of generic office applications.

The ICT competencies, or outcomes, for initial teacher trainees, and serving teachers, were effectively identical. However they were published in slightly different forms, with the requirements for initial teacher trainees modified to advisory language for in-service use. A large number of A4 booklets described the competencies and related them to subject areas for both primary and secondary schools. This exemplification material attempted to place within the curriculum context the kinds of skills that teachers would be expected to use to enhance learning opportunities for student classes.

Table 30: Examples of ICT outcomes for primary teachers in the UK

Outcome Teachers should know... Trainees must be taught how to decide.....	Rationale	Software description	Teaching example
when, and when not, to use ICT	Speed and automatic functions	Talking word processors	Aural feedback in response to writing
		Graphing software	Deciding the best form to present results of a traffic survey
		Mathematics tutorial software	Getting instantaneous feedback on progress
	Capacity and range	Texts from CD-ROM and Internet	Comparing writing styles along a timeline
		Athletics records from CD-ROM and Internet	Discuss the implications of measuring time to increasing accuracy
	Provisional nature of information in ICT environments	Word-processing	Change font size, highlighting key words to support reading
	Interactive nature of ICT	Mathematical simulations	Visualisation of how many things can be halved
how to use ICT effectively to achieve subject-related objectives	Effectiveness rather than for classroom discipline	Word-processing	For drafting and composition, not copy-typing
	Avoiding ICT for lower-level thinking tasks		
	Preparing equipment properly		
	Balancing presentation and content	Word-processing	Track changes between drafts
	Structuring pupil's work	CD-ROM	Use effective search methods for a specific target
	Having high expectations		
	Making links between ICT use, subject matter and everyday life		

Table 31: Examples of ICT outcomes for primary teachers in the UK -
Knowledge and understanding of, and competence with, ICT

Outcome Teachers should show... Trainees must demonstrate	Sub-skill	Example	Use
competence in those areas of ICT which support pedagogy in every subject	Can employ ICT tools and resources at the level of a general user	Connect speakers, headphones, microphones, to a computer	Record and use sound files
	Know and understand the characteristics of information	Speed and ease of updating material on the Internet	Make judgements about reliability and authority of sources
in relation to the subject and pupil's ages	Know how to use ICT to find things out	Using a search engine to locate texts	Import text into different packages and format for different audiences
	Know how to use ICT to try things out	Use number software	Vary number sequences according to a rule
	Know how to use ICT to communicate and exchange ideas	Use fax, phone, e-mail	Match with language skills, compare costs.

The origin of the policies that had led to the development of these materials was in the highest levels of government. It integrated with related policies for e-commerce and the improvement of government services through the use of new technologies. But there was also a strong concern that information technology offered opportunities in the field of education that had hitherto been overlooked.





Turning these opportunities into reality, it was recognised, would take a vast change in the way that teachers did their work. Therefore a large amount of money had been released from the national lottery to enable this training to be provided. The object of the training had been fairly carefully specified, and teacher behaviour was expected to be modified as a result.

6.10.6 Summary

England is using a structured approach to ICT in education, stemming from the national curriculum which has changed focus in this area considerably since its inception. The compulsory nature of the national curriculum has caused tensions amongst teachers, but the policy is intended to be implemented using local strategies, providing opportunity to accommodate local conditions. ICT has become a core subject within this curriculum. From 1998 ICT skills became an essential requirement for pre-service teacher training, and parallel courses have been provided through the national lottery. The emphasis in presenting this training to teachers has been subject-focused, with curriculum applications for improving student learning published ahead of material strictly relating to ICT in associated documentation. The training is estimated to take 40-50 hours over a period of 8 months, and successful implementation is judged by the quality of teacher decision-making about how, when, and when not to use ICT in classroom practice. The rationale for ICT in school education is economic, deriving both from consideration of international competition and also from a need to continually improve educational efficiency.

6.11 Country data

Table 32: Basic parameters for the sample countries

	Estonia 	England 	USA 	Australia 
Population	1,440,000	59,357,000	273,131,000	18,971,000
Area (sq. Km)	43,211	242,432	9,363,130	7,682,300
Population density (persons/km ²)	33	245	29	2.5
Population growth rate	-0.6%	0.2%	0.9%	1%
Schools	724	29,199	89,505	9,587
Gross Domestic Product (billion USD)	\$7.8	\$1,252	\$8,511	\$393.9
GDP per capita	\$5,417	\$21,093	\$31,161	\$20,763
Students/computer	28	7.7	6	12
Student:teacher ratio (primary)	n/a	21.2	18.3	18
Student:teacher ratio (secondary)	n/a	15.5	14	12.8
People per Internet host	48	31	10	18
Rank order for Internet hosts/world	20 th	14 th	3 rd	8 th

Commonwealth of Australia (1998); The Times (1988); Australian Bureau of Statistics (2000); British Embassy, Stockholm (1999); National Center for Education Statistics (2000); U.S. Census Bureau (2000); Central Intelligence Agency (1999); The Library of Congress (2000); Jaana (1998); Nelson (1996); UNESCO Institute for Statistics (1997); Organisation for Economic Co-operation and Development [OECD] (1999); RM (1997); Council of Ministers of Education, Canada (2000); Wu (2000); European Schoolnet Newsdesk (2000); Internet Software Consortium (2000).

6.12 Examples of policy document analysis

6.12.1 Analysis of Circular 4/98 (England)

Text from source	Comment
<p>Circular number 4/98 Annex B: Initial Teacher Training Curriculum for the Use of Information and Communications Technology in Subject Teaching</p> <p>INTRODUCTION IMPORTANT</p> <p>This curriculum is different from those for primary and secondary English, mathematics and science because it does not relate to a particular subject. It is concerned with the ways in which Information and Communications Technology (ICT) can be used effectively in the teaching of other subjects in the pupils' National Curriculum. ICT is more than just another teaching tool. Its potential for improving the quality and standards of pupils' education is significant. Equally, its potential is considerable for supporting teachers, both in their everyday classroom role, for example by reducing the time occupied by the administration associated with it, and in their continuing training and development. It covers the wide range of ICT now available, e.g. computers, the Internet, CDROM and other software, television and radio, video, cameras and other equipment. While it is recognised that many teachers will also be responsible for developing pupils' IT capability using ICT, that is not the focus of this document.</p> <p>The requirements will come into effect from September 1998. The final year of undergraduate courses will be exempt from this requirement for 1998/99 only.</p> <p>For primary trainees, this curriculum applies to training in the core subjects (English, mathematics and science) and their specialist subject(s). For secondary trainees, this curriculum applies to training</p>	<p>Rationale: Argues for the pedagogical rationale.</p> <p>Status: the standards are mandatory for pre-service teacher training</p>

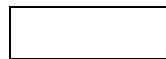
in their specialist subject(s).

The curriculum aims, in particular, to equip every newly qualified teacher with the knowledge, skills and understanding to make sound decisions about when, when not, and how to use ICT effectively in teaching particular subjects. Although this curriculum applies to all trainees, the knowledge, understanding and skills required will often differ between subjects or phases. Some examples are given in the document to illustrate particular points, but it is the responsibility of the ITT provider to ensure that the ways trainees are taught to use ICT are firmly rooted within the relevant subject and phase, rather than teaching how to use ICT generically or as an end in itself.

In order to support providers in this, the TTA proposes to produce separate exemplification, by subject and phase, which can be used in conjunction with this document.

With the introduction of the National Grid for learning, it becomes even more important for newly qualified teachers (NQTs) to be confident and competent in using ICT effectively in their teaching. The ITT curriculum will also form the basis of the Lottery-funded training for serving teachers in the use of ICT.

Providers of ITT must ensure that only those trainees who have shown that they have the knowledge, understanding and skills to use ICT effectively in teaching subject(s) are judged to have successfully completed an ITT course leading to Qualified Teacher Status (QTS). Detailed requirements of what trainees must demonstrate they know, understand and can do before being awarded QTS are set out in the Standards for the Award of Qualified Teacher Status (Annex A).



The National Curriculum for the use of ICT in subject teaching should therefore be read alongside the relevant ITT National Curriculum, where applicable, and the Standards for the Award of Qualified Teacher Status (Annex A).

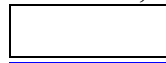
Application:
these standards will also apply to existing qualified teachers.

Every attempt has been made to “future-proof” the content of this document, but ICT is changing rapidly and it will be necessary to keep the curriculum under close review. In order to make the requirements of the ICT curriculum clear to a wide readership, the use of jargon and technical language has been avoided, but the correct terminology has been used where appropriate.

The curriculum is in two sections.

Section A EFFECTIVE TEACHING AND ASSESSMENT METHODS

This section sets out the teaching and assessment methods which, as part of all courses, all trainees must be taught and be able to use. This curriculum focuses on teaching and assessment methods which have a particular relevance to the use of ICT in subject teaching. Trainees must be given opportunities to practise, in taught sessions and in the classroom, those methods and skills described in this section.



Section B TRAINEES’ KNOWLEDGE AND UNDERSTANDING OF, AND COMPETENCE WITH, INFORMATION AND COMMUNICATIONS TECHNOLOGY

6.12.2 Analysis of student standards (Estonia)

Source document	Comment
<p style="text-align: center;">Chapter 3. Information technology and teaching media Part 1. Information technology</p> <p>§ 351. Information technology as a passing subject</p> <p>(1) Developing the competence of information technology in the comprehensive school is not connected with any concrete platform of hard- or software, producing company or set of software.</p> <p>§ 352. The Aims of Learning</p> <p>The aims of teaching <i>information technology</i> as a passing subject are:</p> <p>1) The student understands the economic, social and ethical aspects connected with using information technology;</p> <p>2) The student masters the skills of using information technology independently. omandab infotehnoloogiavahendite iseseisva kasutamise oskused [sic].</p> <p>§ 353. The School-leavers' Competence by the End of Comprehensive School and Gymnasium</p> <p>The school-leaver:</p> <p>1) uses effectively and skillfully the input devices of the computer (mouse, keyboard), output devices (printer, monitor) and the memory devices (diskette, CD-ROM, hard drive);</p> <p>2) knows how to use the graphical interface of the operation system;</p>	<p>Status: mandatory to achieve school-leaving certificate</p> <p>Rationale: economic, social & ethical</p> <p><u>Categories of skill:</u> Operational</p>

<p>3) knows how to use the local network and administer the document files;</p>	
<p>4) can use the correct terminology in his mother tongue when speaking about information technology, can describe the simpler problems connected with hard- and software;</p>	<p>Vocabulary</p>
<p>5) behaves ethically and correctly when using information technology, is aware of the consequences of misuse information technology;</p>	<p>Social, moral & ethical</p>
<p>6) handles the hard- and software with responsibility and economically;</p>	
<p>7) can describe the role of information technology in the society and the importance of that from the aspect of choice of vocation;</p>	
<p>8) is able to plan, create and present interesting texts, multimedia presentations, advertisements etc that have been made independently or in co-operation with classmates using information technology;</p>	<p>Publishing & creativity</p>
<p>9) uses information technology effectively to find information and to communicate on academic aims, chooses the best way to solve the problem or task;</p>	<p>Research & organisation of information Communication</p>
<p>10) understands the necessity of critical evaluation of the Internet resources (is it correct, appropriate, sufficient and objective);</p>	<p>Critical discrimination of digital resources</p>
<p>11) can manage with easier statistical analysis with information technology (frequency, average, diagrams).</p>	<p>Problem Solving</p>

6.13 Issues analysis of interviews with members of the expert panel

The issues analysis extracted meaning from the interviews by allocating significant interview elements to categories (see Burns, 1997, p. 377). This first table shows the conceptual categories that emerged from open coding within each of the research questions (labelled using letter codes A, B, C *etc.*). The subsequent tables show the letter code of the conceptual category each interview element contributed to.

Category codes

RQ1a: What has been the general nature of policies in the USA, England, Estonia and Australia for ICT in school education?	RQ1b: What were the development and implementation processes of these policies?	RQ2: How have government inputs such as ICT frameworks, targeted funding and accreditation requirements influenced the use of computers in schools?	RQ3: What teacher professional development policies & procedures were evident in the countries studied?	RQ4: ICT frameworks and pathways.
A Evidence of a pedagogical rationale.	A Inspirations.	A What general inputs were identified?	A Teacher ICT standards originate in pre-service training, but soon extend to in-service.	A What is the level of satisfaction of the experts about their country's development of ICT in education?
B Evidence of a social rationale.	B Visions of the policy writers.	B What specific inputs were identified?	B In-service ICT professional development requires very careful presentation and pre-conditions	B Which elements of current policy and practice are barriers to ICT adoption?
C Evidence of an economic rationale (1) for national prosperity (2) for working life.	C School application of ICT.	C How did these inputs influence schools?	C How is ICT professional development assessed?	C Which elements of current policies and practices point towards the future?
D What is the idea of I(C)T? Is it a unitary concept in education and how is this kept under constant revision?	D Areas of contention.	D How were the effects monitored?	D How is the effect of ICT professional development evaluated?	D What factors did the experts consider important for future policies and their implementation?

Interview elements and category codes by Research Question

RQ1a		RQ1b		RQ2		RQ3		RQ4	
BM21: The pedagogical rationale for ICT in English education derived from differentiation.	A	BM16: In England the implementation of ICT in education policy is through all subjects.	C	BM 8/10: National curriculum accreditation in England makes ICT mandatory for students.	A	BM26: A pre-requisite for participation in classroom ICT PD was teacher basic skills and a defined level of school computer hardware in England.	B	BM72: The objective of ICT PD in England is at the Phase 2 level (to help a greater proportion of students reach the current benchmarks).	A
BM91: The national curriculum in England was brought into force despite teacher criticism.	A	BM21: There were common origins for ICT policies in USA and England. [AI Gore] [COMPARE ESTONIA]	A			BM27: The lottery funded ICT training was the biggest ever PD project in England.	B	BM75: Kid plus machine is different than kid.	E
DM46: Current standards for ICT in education don't go far enough – constant revision is necessary in the light of technological improvement.	D	BM103 & 110: many ICT initiatives are proceeding in English education without interconnection.	D	DM23: The states of the USA are following the federal lead in respect of setting ICT standards for students.	A	BM32/33: The English ICT PD in-service programme was exposed to competitive market forces.	B	BM79: Perkins redefines the concept of ability when working with ICT.	E
EM46: The Estonian curriculum has historically been based upon knowledge of facts with set contact times per week for each subject. [LINK to NM]	B	BM120-126: The policy for ICT in education in England was influenced by national curriculum, inspectorate & government modernisation programme.	A	DM76: Some evaluations of ICT have compared performance on standard tests. Which is only OK if the expected outcome from education is test performance. [LINK TO LIT REVIEW]	D	BM36: the objectives of the ICT PD in England were confused.	?	DM20: Current ICT standards are mundane.	A
EM46: If ICT can bring about changes in Estonian society, then it can also bring about changes to Estonian education.	B	DM3: The 1983 report 'a nation at risk' in the USA was a spur for curriculum reform.	A			BM38: Differentiation was applied to the ICT PD itself in England.	B	DM20: Man + machine is a good learning combination.	E

Appendices

RQ1a		RQ1b		RQ2		RQ3		RQ4	
EM59: One view is that ICT has no value of itself – but it can improve teaching effectiveness in all subjects.	A	DM36: In the USA education has become an area it is politically desirable to support.	A			BM43: An example of a PD activity – make a set of ‘favourites’ for a teaching activity.	B	DM21: New disciplines are arising because of ICT.	E
MR11: ICT policy in England suggests three ways to use computers: -as a subject in its own right -to improve teaching in other subjects or embedded within them -or in CAD/CAM where they are essential to the subject. [COMPARE MOTPD]	A	DM41: Standards development in the USA was bottom-up.	A	KB89: Despite its status in the National Curriculum, there was no national testing of ICT in England (as there was for English, Maths and Science).	D	BM44: ICT PD needs to be 40-50 hours.	B	DM66+67: Independent learning in the NETS (USA) standards only got a small mention because they were working to the lowest common level and many of the planning group were against computer aided learning. [LINK BARBER, 1999]	B
MR31 & 61: Micro-electronics and control technology is compulsory for all students in the English Design and Technology subject of the national curriculum.	C 1	KB105: It’s unlikely the planners of the original 1990 national curriculum in England had a clear view about the nature of ICT.	B			DM15+17: In the USA pre-service teachers cannot meet ICT standards for G8 students.	B	DM81: Standards are a step on the road to ‘changing the purpose of education’, with independent learning an important part of this change.	D
MR65&69: IT capability was brought into the English national curriculum for all students in all subjects because of the determination of the planning group who used the economic rationale as justification.	C 2	KB107: There is evidence that the use of bespoke software for education is declining and is being replaced by generic office software.	C			DM84: 12 hours ICT PD a year is not enough to stay current with the operation of office packages, let alone be transformative.	B	DM81: The need for transformation is illustrated by the proportion of knowledge advances emanating from multi-disciplinary teams.	E

Appendices

RQ1a		RQ1b		RQ2		RQ3		Model	
MR125: In England, IT is a core subject alongside literacy, numeracy, religious education and science.	A	KB155: In England, the fortunes of politicians hang heavily upon ICT being effective in education, because they have invested so much money in it.	A	TE128: Adoption of ICT in Estonian basic and primary schools has been greater than for other sectors because they have a more flexible timetable and less high-stakes accreditation requirements.	C	EM1: You need a lot of PD time for in-service ICT PD. [LINK TO DM84]	B	DM82: the potential for radical change is illustrated by comparing the power of a 1999 Mac G4 which is similar to that used for forecasting USA weather in 1994.	E
MR127: Micro-electronics for all in England has not yet had the desired economic effect.	C 1	MR19: The original national curriculum in England was planned by subject groups who did not inter-relate.	D	DM4: Title 1 (socio-economic status) money was used by Federal government to put IT into USA schools.	B	EM1: Initial teacher training does not change quickly enough to respond to ICT	A	EM9: ICT should integrate subjects together (enhance cross-disciplinary links).	E
DM4: The USA education system originated in 1900s.	D	MR53: the impetus for the introduction of a national curriculum in England was a political desire to centralise control over school education. This was shown by Ministerial feedback on early drafts on the History syllabus which asked for less contextual understanding, more knowledge of dates.	A	DM9: The 'Free' web-site makes US govt material available to schools as an information resource. (Kickbush, 1998)	B	EM64 & 66: ICT PD is needed to overcome the professional fears of students who know more about ICT than they do. [LINK TO MR & KB in England]	B	EM13: The Estonian vertebrates web-site provides tests and supportive material that would not fit on the CD-ROM.	C
MR53: The IT subject was included in the English national curriculum because of its perceived economic importance to the country.	C 1	MR101&113: In England, centralisation of education was presented as devolution, and schools were bought out of local authority control by additional resource allocations.	A	NM182: the National Grid for learning was designed to distribute educational materials.	B	EM89: PD links to curriculum change.	D	EM86: ICT changes the nature of student-teacher relationships.	D

Appendices

RQ1a		RQ1b		RQ2		RQ3		RQ4	
MR133: In England there have been difficulties getting IT incorporated into the curriculum for the final years of schooling because of overcrowding. [COMPARE ESTONIA]	B	MR123: IT capability is more than how to use software packages: its learning critically about practical applications of IT as well as using it to achieve learning outcomes for particular subjects.	B	MR185: you can share educational thinking through the National Grid for learning.	B	KB11: In England it was difficult to link PD and curriculum because they were supervised by two different organizations. [LINK TO EM89]	D	KB195: A transformative phase is incorporated into the English national curriculum (2000) since it specifies topics that cannot be taught without ICT.	C
BM143: English policy is mute on areas of incompatibility – ie ‘class teaching of the basics’ and ICT-enhanced learner autonomy.	D	TE21, 36&68: It took three attempts to get an explanation of the national policy to ICT across the curriculum. ICT is generally a theme to be handled at every level of school, and basic school graduates should know how to use computers in their work.	B			KB21: In England the ICT standards for pre and In-service teachers were linked. [LINK TO DM]	A / B	KB199: Chris Woodhead (chief HMI in England until his resignation in Nov 2000) maintained that schools 20 years from now would still look the same. Stephen Heppell disagreed. There is no consensus about the overall direction we are going.	D
		TE57: the difficulty of translating software into the local language has been a barrier to ICT adoption in Estonia.	D			KB59: There can often be a mis-match between the perceptions of a particular activity when teachers believe a subject is being studied, and students believe they are learning about ICT.	D	KB202: There are schools in England with virtual classes with their learning materials online. For instance in small secondary schools in Wales, or the Highlands and Islands of Scotland.	C
		TE58: local software development is crucial to ICT adoption.	D			KB137: The criterion for successful ICT PD is the subsequent quality of teacher decision-making.	C	MR134: In England examination boards do not permit submission of desktop published material because of the difficulties of authentication and plagiarism.	B

Appendices

RQ1a	RQ1b	RQ2	RQ3	RQ4	
	NM14-15: There was tension in the design process of the 1990 national curriculum between practice and policy.	B	KB163: There is a mismatch between the ICT standards for students and those for teachers.	D MR144: Evidence of English level = Phase 2: a school in Manchester got home computers for all students and used RM PIC to allow home access to learning materials based upon the current curriculum.	C
	TE200: In Estonia students have been known to use online translation engines to help with their foreign language homework.	D	MR191: All pre-service teachers in England are required to demonstrate competence at using ICT to teach in their area of specialism.	A MR164: There is an analogy between literacy and IT in England – both can be taught across the curriculum.	C
	NM10: The original technology subject was drawn up for the English national curriculum (1990) by a group chaired by Lady Parks (previously chair of NCET etc), and with members John Hammon (City University), Paddy O’Hagen (teacher), Ben Kelosly (business studies teacher, Hampshire), Andy Bracken (CEO design and technology association), David Leighton (Professor of science Education, Leeds University) and an IT person from industry.	B	MR195: All in-service teachers in England are being given the chance to be trained to use ICT to the same standards as those expected of pre-service teachers. This is encouraged by advertising and requirements for career progression.	A/ B TE13: Estonia ‘skipped’ a stage of development and missed having both Macintosh computers and early PCs.	D

Appendices

RQ1a	RQ1b	RQ2	RQ3	RQ4	
	NM22: Whether IT was taught across the curriculum was a school-level choice for the English 1990 national curriculum: the legal requirement defined what should be taught, not how.	C	MR211: the standards for ICT PD in England are deliberately organised with teaching applications first, and personal skills second.	B TE80: Estonia skipped a development stage by going straight to wireless broadband Internet connections for schools.	D
	NM50 & 56The planning group for the 1995 English national curriculum found it advantageous to confound the rationales for ICT as a tool for lifelong learning and employability. Employability is a sub-branch of the economic rationale.	B	MR231: Teachers can determine their ICT training needs in England by using the needs assessment CD-ROMs.	B TE106&110: There was evidence of transformative developments in Estonia when web pages and email were used to support distance education due to the lack of specialist teachers of biology for 17 year old students.	C
	NM114: The question of improved effectiveness or the pedagogical rationale for ICT entered into UK policy thinking with the Stevenson report (1997).	C	MR239: ICT PD in England focuses on the subject to be taught, not the technology.	B TE 174: Estonia skipped a stage of development by using Unix servers in its schools.	D
	NM182: Schemes of work to accompany the national curriculum were used by 75% of schools.	C 2	TE138: the cost of formal ECDL ICT PD accreditation was too high for Estonia, but nevertheless was used as a framework for the training.	B EM115: Example of implementation skipping steps: Estonia went straight to wireless Internet connectivity.	D

Appendices

RQ1a	RQ1b	RQ2	RQ3	RQ4
	NM192 & 204: Material bridging current teacher skills and understanding with policy expectations for practice should be attractive and disposable, distributed together with national curriculum requirements which should be plain and unattractive by comparison.	C 2	TE148: Teacher ICT skill assessment needs to be done using authentic situations, not on-line drills.	C NM6: New subjects do arise: cf ICT itself in the English National Curriculum 1990.
	DM82: Exemplification materials for the NETS (USA) standards illustrate how ICT can support the existing curriculum, not show how ICT can transform education.	D	TE184: Teachers will not use student-accessible computers to develop their ICT skills.	A/ B NM28: Policy needs to be commensurate with teacher skills and societal expectations: there has to be a balance between low-level button pushing skills in the ICT area, and a higher vision.
	TE54: New high-stakes examinations in Estonia at the end of schooling are barriers to ICT adoption for this age group. [COMPARE ENGLAND]	D	DM33: In the USA ICT standards for teachers started with pre-service and were extended to in-service [AS ENGLAND - MR191]	A/ B NM34: As one of the designers of the English national curriculum for 1995, NM saw IT as an organic whole, not a bag of bits.
			DM38: a single person (Lejeane Thoms) was responsible for initiating the move to ICT standards for teachers in the USA.	A NM64: Many schools interpreted the original national curriculum requirements for IT as training at the level of Phase 1: training in keyboard skills.

Appendices

RQ1a	RQ1b	RQ2	RQ3	RQ4
			DM60: Florida put 30% of ICT money into staff development	B NM72: Explanatory materials to help schools understand how to implement the English 1990 national curriculum IT subject area were largely ignored by schools B
			KB57: Significant funds were spent on ICT PD in England following directives from top-level government.	B NM146: An example of how ICT can transform a subject would be the study of dialects when learning a foreign language. E
			KB151: The English government was looking for a change in teacher attitude to ICT. Funding targeted at ICT PD was expected to produce this	B NM154: An historical example of curriculum transformation is given by the emergence of English degrees in the last 150 years. Previously only Greats or Classics were taught. E
				NM169: Internet links between home and school can be used to replicate practice at the level of Phase 2, but they can also be used transformatively. C
				DM60: Implementation of ICT in education policy in the USA has been generally poor [Compare NM in UK] A

6.14 The commonality of student curriculum frameworks

Table 33: Similarities of student curriculum framework strand organisers in the case study states.

Locale	Title	Part of	Policy date	Strand Organisers (arranged in columns of similar intent)						
Alberta, Canada	Information and Communication technology (k-12) - an interim program of studies		1998	Foundational operations, knowledge and concepts	Processes for productivity	Communicating	Inquiring	Decision - making and problem solving		
Australian Capital Territory, Australia			1999		Authoring including word processing and Web design: Presentation and visual display processes and tools	Communication and collaboration , including e-mail and groupware	Information Access: Organisational processes and tools such as database packages			
England, U.K.	Information and Communication Technology	National Curriculum	2000		Reviewing, modifying and evaluating work as it progresses	Exchanging and sharing information	Finding things out	Developing ideas and making things happen		
Hong Kong	Information Technology Learning Targets		1999	Skills			Knowledge			Attitudes
Tasmania and other states of Australia (unofficial)	KITOs - Key Information Technology Outcomes		1997	Operations and computer components	Publishing	Communicating	Researching	Problem Solving	Independent Learning	
United States of America	National Educational Technology Standards for students	International Society for Technology in Education	1998	Basic operations and concepts	Technology productivity tools	Technology communications tools	Technology research tools	Technology problem-solving and decision-making tools		Social, ethical, and human issues
Victoria, Australia		Curriculum and Standards Framework	1997	File Management	Word Processing: Graphics: Multimedia: Desktop Publishing	Electronic Communication	Database	Spreadsheet: Simulation/ Modelling		

Table sources: Alberta Education, 1998; ACT Department of Education, Youth and Family Services, 2000; Qualifications and Curriculum Authority, 2002; Information Technology Learning Targets Working Group, 1999; Computer Education Discussion Group, 1997; International Society for Technology in Education, 1998; Board of Studies, Victoria, 1997.

6.15 Establishment of critical values for transitions between Phases

Table 34: Summary of Phase transition indicators from case studies for the general model

	Attribute	Introductory Phase 1	Integrative Phase 2	Transformative Phase 3		
Student use of ICT	% with home computer access	1%	50%	90%	99%+	
	% with home Internet access	none	25%	90-95%	more	
	% of learning using computers (for average student age 11)	1%	3%	10%	20%	
ICT professional development for teachers	Skill Standards	Some specialist IT teachers	Basic operational skills for all teachers	ICT integration	Some have ICT management skills and/or do on-line teaching	Most use ICT to monitor student progress
	Software use in the classroom	none	Office tools	Library of curriculum software	Development tools and Internet services	On-line content and multi-media tutorial systems
School implementation	Students per computer	28	6		1 (including home-based systems)	
	School networking	None	Partial	Entirely	Accessible from home	Accessible world-wide
	Internet connection/500 students	None	1M bps	2.88M bps		ADSL (256kbits to 1.5Mbs)
	Server space /client	None	E-mail	10M bytes	100Mbytes	Practically unlimited
	Workstation types	32k RAM, 8 bit processor	486 PC	Multi-media	Fast multi-media	DVD with voice recognition
	Frameworks for student ICT learning outcomes	Basic IT skills/IT literacy	Penetrating into all subject areas using an applications template	Embedded in all subjects and integrating between them	Balance of modes in all curriculum areas	ICT vital to most study topics
	Internet access control	N/A	Access restricted to limited number of supervised workstations	Net-Nanny or other filtering	Acceptable Use Agreements	None
Government intentions/philosophy	Infrastructure	Assistance to provide 1 computer per school	Geared/matched funding to promote ICT	Modernisation through ICT	Application-renting agreements	Diagnostic software production
	Policy rationale & policy instruments	N/A	ICT skills for employment	Equity of service provision through ICTs	Endorsement of “virtual practicuum”	Sponsorship of socialisation activities as an alternative to schools.

6.16 The preparedness of Australian states for transformative Phase 3

Table 35: Australian states and their preparedness for transformative Phase 3.

State	Professional development			Infrastructure		Curriculum frameworks and preparedness for transformative Phase 3	
	ICT basic skills	ICT classroom integration	ICT skills for on-line and independent learning	Student: computer ratio	Bandwidth per school (Kbits/s) ₁	Quality of framework for ICT across the curriculum	Readiness for Phase 3
ACT	Information Literacy training. Developing and maintaining IT competencies ²	WebQuests	The O'Connell Information and Resource Centre	4.6:1 ⁶	64.29	Grade 10 IT skills certification	Software acquisition Stage 4: mapped against curriculum requirements on whole school basis, accessible from home
NSW	TILT	TILT+		11:1 ⁴	29.23		
NT	n/a	Maths - No Fear! Project ⁵	Create & Communicate project	Improve Access Improve Opportunity and LATIS projects	9.03	Principal directed pilots Making IT work	Open Learning Support Unit.
QLD	55 per cent of teachers to achieve the minimum standards for teachers learning technology by 2001 ³	n/a	n/a	? better than other states ⁷	79.77	Multi-literacies	Virtual School (but only for distance education)
SA	High levels of staff competence were identified in basic computing operation and word processing;	middle range competence for integration ⁸	Relatively low level competence in Internet use ⁸	5:1 (2001 target) ⁸	11.59		
WA	Notebooks for teachers scheme			5:1 (secondary) 10:1 (primary) (2002 targets) ⁹	63.99		
Tas	IRT (basic skills): 90% of state school teachers have done at least one ICT training module			6:1	27.60		
Vic	Laptops for teachers scheme	67% of teachers reported intermediate or advanced IT skills ¹⁰		4.65:1 ¹¹	46.09	Applications based	

(Sources: ¹ Moon, 1999; ² Nethercott, 2000; ³ Education Queensland (2000c); ⁴ Department of Education and Training, NSW (2000) p 106; ⁵ Northern Territory Department of Education, 2000; ⁶ ACT Department of Education & Community Services, 2000; ⁷ Education Queensland, 2000d p 29; ⁸ Department of Education, Training and Employment, SA 2000; ⁹ Vardon, 1998; ¹⁰ Department of Education, Employment and Training (Victoria), 2000, p. 32; ¹¹ *ibid*, p 43)

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6.17 List of published papers attached to the thesis

These papers are attached in accordance with University of Tasmania guidelines for thesis preparation (University of Tasmania, 2003, p. 23).

Fluck, Andrew E. (1997) Choosing and implementing a model for the cross-curriculum use of computers in schools. *Tel*Ed'97, 6th International Conference on Telecommunications and Multimedia in Education, November 13-16, Mexico City.*

Fluck, Andrew E. (1998) The KITOs - Key Information Technology Outcomes for school students. *Proceedings, Australian Conference on Computers in Education, Adelaide, Aust.* Online at http://www.cegsa.sa.edu.au/acec98/papers/p_fluck.html

Fluck, Andrew E. (2000) Social effects of new technology in schools (SENTIS) –where do we go from here? *Proceedings, Australasian Conference on Computer Education, July 6-9, 2000, Melbourne, Aust.*

Fluck, Andrew E. (2000) Some national and state approaches to integrating IT in education. *Proceedings, Australasian Conference on Computer Education, July 6-9, 2000, Melbourne, Aust.*

Fluck, Andrew E. (2000) A model for initial teacher ICT training. *Proceedings, Australasian Conference on Computer Education, July 6-9, 2000, Melbourne, Aust.*

Fluck, Andrew E. (2001) Some national and regional frameworks for integrating information and communication technology into school education. *Educational Technology & Society* 4(3). Online at http://ifets.massey.ac.nz/periodical/vol_3_2001/fluck.pdf

Fluck, Andrew E. (2003) Why isn't ICT as effective as it ought to be in school education? *Proceedings, ICT and the teacher of the future, International Federation for Information Processing working groups 3.1 and 3.3 working conference, January 26-31, 2003, Melbourne, Australia.* Anne McDougall, John S. Murnane, Carol Stacey & Carolyn Dowling (Eds.). Sydney: Australian Computer Society