1. ICT in the Knowledge-Based Economy

1.1 The Knowledge-Based Economy

Many of the recent transformations in national economic policies around the world have been in the context of a drive towards the *knowledge-based economy* (OECD 1996, 2001) (APEC 2000, 2001, 2002) (ESA 2002) (Houghton 2002b) (ACG 2002) (ABS 2002b). This type of economy is also commonly referred to as the *information economy*, *digital economy* or *new economy*. The term 'knowledge-based economy', or KBE, was coined by the OECD. They defined the term as an economy "*directly based on the production, distribution and use of knowledge and information*" (OECD, 1996). This relentless drive is based on the belief in the benefits of an economy fundamentally different from the ones that existed prior to the mid-1990s[2]. This belief has support in strong quarters, none more so than the chairman of the U.S. Federal Reserve, Alan Greenspan. He described in 1998 that the U.S. economy is going through,

> *"… what can be best described as another industrial revolution. The rapid acceleration of computer and teleCommunication technologies is a major reason for the appreciable increase in our productivity in this expansion, and is likely to continue to be a significant force for expanding standards of living into the twenty-first century."*
>
> (quoted on page 6, DoC 1999)

There have been widespread efforts in quantifying the factors and dimensions of this KBE. A significant development in this is the OECD's two-year project called the *Growth Project*. The project concluded in 2001 with a final report *The New Economy: Beyond the Hype* (OECD, 2001a). That report identifies the following as key aspects to the new economy:

- Information and Communication Technology as an enabling technology
- An innovative environment
- Human capital
- Entrepreneurial climate
- Economic and social fundamentals

APEC also ran a parallel project from mid-1999 called *Towards Knowledge-Based Economy in APEC*. The project culminated in a report in November 2000 (APEC 2000). The report identified similar dimensions to the KBE as OECD's Growth Project. They are:

- Innovation System
- Human Resource Development
- ICT Infrastructure
- Business Environment

In the Australian context, the Australian Bureau of Statistics (ABS) is currently consulting on a new framework for dimensions and indicators for KBE (ABS 2002b). Since the ABS framework is built on OECD and APEC's work, it therefore lists similar dimensions to those concluded by OECD and APEC. The dimensions are diagrammed in Figure 1.1. Details of framework are found in Appendix B.

[2] Associated with this change to the economy is what is believed to be an equivalent, less understood, change to society in general. Terms like *the Knowledge-Based Society* and *Information Society* are used to characterise this. Readers are referred to Lee (2002) for further discussions.

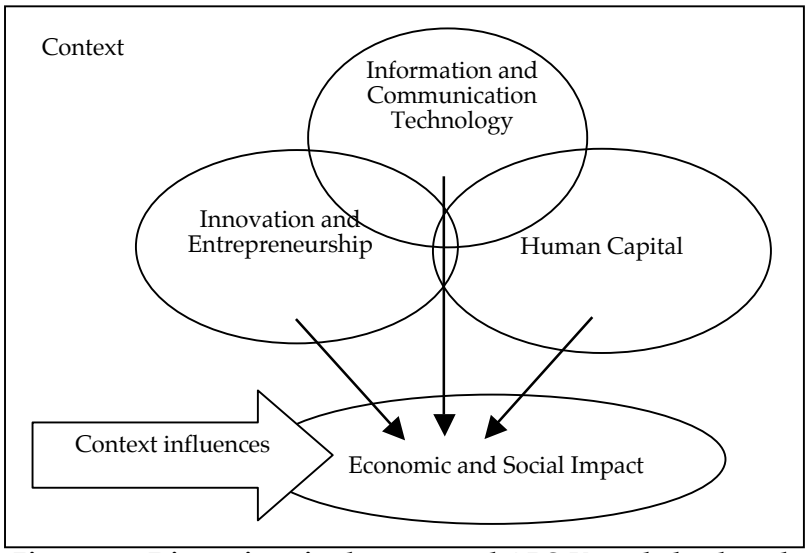

Figure 1.1: Dimensions in the proposed ABS Knowledge-based Economy/Society Framework. Source: ABS (2002b) page 15.

In all of these analyses, we see that Information and Communication Technology (ICT)[3] plays a very prominent role in this new economy. Many hold the belief that the main reason for the changes to the economy was the widespread diffusion of ICT within various industries[4]. This new ICT sector has the properties of many fundamental enabling technologies in the past: they are general-purpose, applicable to many areas, and capable of changing the basic processes of work and recreation.

In spite of ICT's importance, it is widely accepted that considerations for the KBE should not be concentrated only on the technology sectors. As noted in the *Towards Knowledge-Based Economy in APEC* report:

> *… being a KBE means more than simply having a thriving "new economy" or "information economy" that is somehow separate from a stagnant "old economy". In a truly knowledge-based economy, all sectors have become knowledge-intensive, not just those usually called "high technology".* (APEC 2000, page vii)

1.2 Definitions and Measurements of ICT

There are many ways to view ICT in the context of our economy and society. The term can cover the basic production through manufacture and services, through to distribution, usage, diffusion, content development, and so on. With the prevalence of these various aspects of ICT, there have been many international efforts[5] in defining and measuring the various aspects of ICT. In this section, we summarise the major efforts.

[3] In this report, we will refer to ICT as "*Information and Communication Technology*". However, note that there isn't total agreement in the literature on the expansion for this acronym. Some refer to "*Information and Communication**s** Technology*", as well as "*Information and Communication**s** Technolog**ies***". There are also other commonly used terms to refer to the same field, such as "*Information Technology and Telecommunications*" (IT&T), and "*Networking and Information Technology*".

[4] See references already listed in this section. There are, of course, opposing views as well. For example Gordon (2000) challenges the claim that ICT can match the technology revolutions of the past, like electricity and internal combustion engine, or even movies, radio and indoor plumbing.

[5] Example see reviews in Jeskanen-Sundström (2001) and ABS (2002b)

The most active international body in developing definitions and measurements of ICT is the OECD, with heavy influences by the Voorburg Group from the United Nations Department of Economic and Social Affairs Statistics Division. It has extensive work in defining the ICT sector, the outputs of this sector, and their application to various other sectors[6].

Industrial Definition of the ICT

In the late 1990s, as ICT activities became prevalent, OECD countries started to recognise the importance of measuring ICT as an industrial sector. This led to the formation of an ad-hoc statistical experts group under the Information, Computer and Communication Policy (ICCP) Division in 1997. In 1998, this group became the Working Party on Indicators for the Information Society (WPIIS). WPIIS began working on drafts of a definition using the International Standard Industrial Classification of All Economic Activities (ISIC Rev.3). The principles underlying the definition were (Roberts 2001):

- For manufacturing industries, the products of a candidate industry must be intended to fulfil the function of information processing and communication including transmission and display or must use electronic processing to detect, measure and/or record physical phenomena or to control a physical process.
- For services industries, the products of a candidate industry must be intended to enable the function of information processing and communication by electronic means.

As an indication of prevailing thoughts at the time, the following diagram was used in a 1997 draft[7] to indicate what ICT production and distribution activities consisted of:

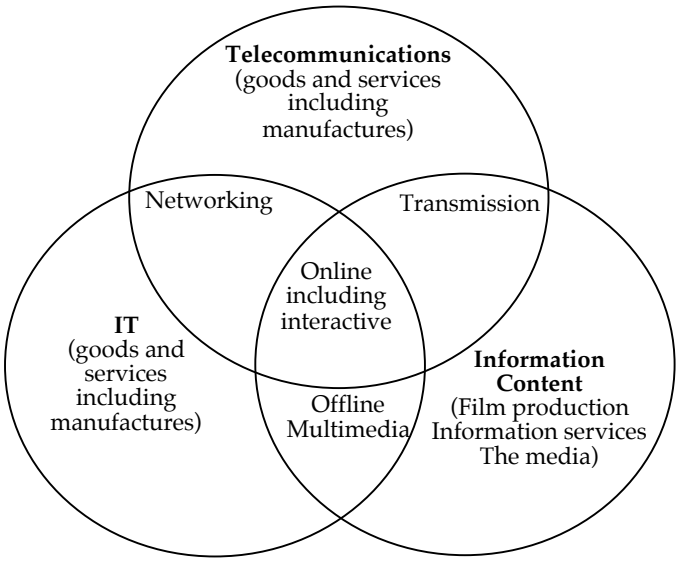

Figure 1.2: ICT Production and Distribution activities. Source: http://www2.dst.dk/internet/voorburg/pdf/3_3.pdf.

[6] For elaborations, see review in Roberts (2001) and Pattinson (2000).
[7] Full draft available at http://www2.dst.dk/internet/voorburg/pdf/3_3.pdf. This draft was produced by the Statistical Panel of OECD's ICCP Division as a discussion paper at the September 1997 Voorburg meeting.

In 1998, the WPIIS reached a consensus on a basic definition (OECD 2001). This definition of the "ICT sector" included the following ISIC Rev 3 industry classes:

- Manufacturing:
    - 3000 – Office, accounting and computing machinery;
    - 3130 – Insulated wire and cable;
    - 3210 – Electronic valves and tubes and other electronic components;
    - 3220 – Television and radio transmitters and apparatus for line telephony and line telegraphy;
    - 3230 – Television and radio receivers, sound or video recording or reproducing apparatus and associated goods;
    - 3312 – Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment;
    - 3313 – Industrial process equipment.
- Services:
    - 5150 – Wholesaling of machinery, equipment and supplies (if possible only the wholesaling of ICT goods should be included);
    - 7123 – Renting of office machinery and equipment (including computers);
    - 6420 – Telecommunications;
    - 72 – Computer and related activities.

OECD uses the ISIC Rev 3 classification system even through it recognises that ISIC Rev 3 does not cover all (potentially) ICT-related activities. Unfortunately, no better alternative existed. For this reason, individual countries have combined other data sources with their own versions of industrial classifications[8] to derive ICT aggregates in national accounts and other statistical collections. Even when using ISIC Rev 3, the classes were not uniformly applied by the different countries. For these reasons, data published from different countries needs to be constantly modified when used for comparative purposes, to adjust for the methodologies of the times.

The OECD definition is not static, and undergoes reviews due to changes in ICT activities. The latest review in April 2002 concluded that the 1998 definition was still adequate and decided against making any changes at that stage. One of the predominant review questions in an industry-based definition such as this is whether a certain industry class contains sufficient ICT activities to be included in the definition[9]. OECD expects that as prevailing industrial activities relating to the technologies change, classes will be included and/or removed accordingly.

Commodity-Based Definition of the ICT

Having defined the ICT sector based on industrial activities, the OECD is moving towards defining the sector based on ICT commodity products. Similar to the principals underlying the industry-based definition, the commodity-based definition aims to define a set of products that are

[8] Major ISIC related classification systems in different countries include the *Australian and New Zealand Industrial Classification* (ANZSIC) in Australia, *North American Industry Classification System* (NAICS-USA) in the United States, and *General Industrial Classification of Economic Activities* (NACE) within European Communities. See http://unstats.un.org/unsd/class/family/famlist1.htm for details of these systems. See Appendix 1 Table A.1 in OECD (2002b) for chart comparing the different systems.

[9] Example, see the Sept 2001 review at a meeting in Örebro, Sweden <http://www.voorburg.scb.se/ICTsector_voorburg.doc>.

- intended to fulfil ICT-related functions by electronic means, including transmission and display, or
- use electronic processing to detect, measure and/or record physical phenomena, or control a process.

For the commodity-based definition, OECD uses the international Central Product Classification (CPS) for goods and services production, and the Harmonised System for data on international trade. However, these systems have to be modified since they specifically identify ICT products, and they are relatively old and hence do not include recent goods and services coming from ICT.

Definition of Electronic Content

The WPIIS is also working on defining an *Electronic Content* sector, as the sector that produces the information content. This is a rapidly growing sector. The definition is meant to be used in contrast and in conjunction with the definition of the ICT sector above, which only deals with the infrastructure that stores, displays, transmits and processes the information. Progress in this regard has been slow and has not been a priority.

ICT Diffusion

Another important category of measurement in ICT is how and to what extent ICT outputs are diffused across the economy. In this aspect of ICT measurement, there is less need for a "definition". Work has concentrated on developing model surveys of the use of ICT goods and services across all sectors of the economy, including the Business sector, the Government sector and the Household sector. Australia has also taken a lead role internationally in measuring ICT diffusion in the Farming sector.

E-Commerce

The OECD and the European Union have focussed very heavily on defining electronic business processes carried out using ICT technologies and applications. The impetus for this work comes from the OECD *E-Commerce Action Plan* endorsed by Ministers at the 1998 Ottawa Conference on Electronic Commerce. In line with this, the WPIIS created an Expert Group on Defining and Measuring E-Commerce in 1999.

The Expert Group categorised three initial sets of indicators required for policy purposes:

- **E-Readiness**: measuring the infrastructure in place to allow for e-commerce activities to occur,
- **E-Intensity**: measuring the extent to which users are utilising e-commerce to undertake their normal business and social processes, and
- **E-Impacts**: measuring the impact of e-commerce on the economy and society

In 2000, the Expert Group also provided a broad and a narrow definition of E-Commerce Transactions:

- Broad Definition: *An **electronic transaction** is the sale or purchase of goods or services, whether between businesses, households, individuals, governments, and other public or private organisations, conducted over **computer-mediated networks**. The goods and services are ordered over those networks, but the payment and the ultimate delivery of the good or service may be conducted on or off-line.*

- Narrow Definition: *An **Internet transaction** is the sale or purchase of goods or services, whether between businesses, households, individuals, governments, and other public or private organisations, conducted over **the Internet**. The goods and services are ordered over the Internet, but the payment and the ultimate delivery of the goods and servicse may be conducted on or off-line.*

Refer to Pattinson (2000), and chapter 4: *E-Commerce Intensity* in OECD (2002b) for further details of work in defining E-Commerce.

Australian Bureau of Statistics

The Australian Bureau of Statistics (ABS) collects data on indicators of the ICT industrial sector (or more commonly called IT&T in past ABS terminology) in Australia for national accounts purposes. The ABS data uses the Australian and New Zealand Standard Industrial Classification (ANZSIC) to classify IT&T activities. ABS uses the following ANZSIC industries for IT&T surveys:

- Manufacturing
  - 2430 Recorded Media Manufacturing and Publishing (from 1998-99)
  - 2841 Computer and Business Machine Manufacturing
  - 2842 Telecommunication, Broadcasting and Transceiving Equipment Manufacturing
  - 2849 Electronic Equipment Manufacturing nec
  - 2852 Electric Cable and Wire Manufacturing
- Wholesale Trade
  - 4613 Computer Wholesaling
  - 4614 Business Machine Wholesaling nec
  - 4615 Electrical and Electronic Equipment Wholesaling nec
- Telecommunications
  - 7120 Telecommunication Services
- Computer Services
  - 7831 Data Processing Services
  - 7832 Information Storage and Retrieval Services
  - 7833 Computer Maintenance Services
  - 7834 Computer Consultancy

ABS deliberately leaves out a few of the equivalent categories covered under the OECD ICT industrial definition. ABS determined that in Australia, a few of the minor sub-categories do not involve significant amount of ICT activities to warrant inclusion.

Besides the manufacturing and service production activities covered under the ICT sector, ABS also collects a significant amount of data on the diffusion and usage of ICT in other sectors. Refer to the links for ABS in Appendix A for the full set of statistics.

United Nations and ITU

The United Nations main interest in ICT indicators is in their relation to global social progress. In September 2000, 147 heads of government and 189 nations under the United Nations banner made a *Millennium Declaration*[10]. The declaration was founded on social and economic developments targeted at freeing the human race from want. Of the 18 targets stated, target number 18 relates to ICT. The target is stated as, *"In cooperation with the private sector, make available the benefits of new*

[10] http://unstats.un.org/unsd/mi/mi_highlights.asp

technologies, especially information and communications". The two indicators used for this target are:

- Telephone lines and cellular subscribers per 100 population, and
- Personal computers in use per 100 population and Internet users per 100 population

Both these indicators are officially measured and released[11] by the International Telecommunications Union (ITU). ITU also uses and publishes a more comprehensive set of communications and network indicators[12].

Other ICT Economic Statistics Collection

Some sections of the research community have attempted to measure the ICT status by combining different indicators for form indices. Some examples of these are the *Index of Technological Progress* by Rodriguez and Wilson (Rodriguez and Wilson, 2000), InfoDev's *E-Readiness Index* (InfoDev, 2001), *Technology Achievement Index* by Desai et al (Desai et al, 2002), and *E-business Readiness Index* by the Economist Intelligence Unit (EIU 2001, 2002).

ICT Defined as Academic Body of Knowledge

See section 4.3 and Appendix D for an overview of ICT-related areas as an academic body of knowledge.

1.3 Current Statistics on ICT in Australia

Compared to the many other major economies in the world, Australia has a very minor ICT production sector (Houghton 2001, 2002, and ABS data). Table 1.1 shows some key statistics on the Australian ICT sector as of June 2001, as released by the Australian Bureau of Statistics.

Table 1.1: Australian ICT Sector - Summary of Operations (June 2001)

	Businesses	Persons Employed	IT&T income	Total income	Wages and salaries	Industry value added
	no.	no.	$m	$m	$m	$m
IT&T SPECIALISTS						
Manufacturing						
Computer and business machines	282	3,398	1,311.3	1,342.7	137.6	227.9
Telecommunication, broadcasting and transceiving equipment	188	8,373	1,914.0	2,340.5	555.8	815.3
Electronic equipment n.e.c.	-	-	-	-	-	-
Electric cable and wire	28	928	430.2	469.7	55.6	139.9
Total Manufacturing	**497**	**12,699**	**3,655.4**	**4,152.9**	**749.0**	**1,183.0**
Wholesale trade						
Computers	2,320	38,656	20,271.2	20,618.3	2,148.2	3,057.6
Business machines and electrical and electronic equipment n.e.c.	483	12,327	6,072.5	6,704.4	902.2	1,056.3
Total Wholesale trade	**2,803**	**50,983**	**26,343.7**	**27,322.7**	**3,050.4**	**4,113.9**

[11] Regular publications of the indicators can be found at http://unstats.un.org/unsd/mi/mi_goals.asp.
[12] See http://www.itu.int/ITU-D/ict/.

Telecommunication services	**814**	**77,275**	**29,827.1**	**31,504.8**	**4,651.3**	**15,478.4**
Computer services						
Data processing	485	3,718	*443.2	*477.3	154.3	*263.1
Information storage and retrieval	33	1,174	141.7	150.0	49.0	73.6
Computer maintenance	457	4,451	944.4	983.2	252.6	337.9
Computer consultancy	17,386	88,222	12,411.6	12,927.3	5,154.6	6,761.5
Total Computer services	**18,361**	**97,565**	**13,940.9**	**14,537.8**	**5,610.5**	**7,436.0**
Total	**22,475**	**238,521**	**73,767.1**	**77,518.2**	**14,061.1**	**28,211.3**
OTHER BUSINESSES						
Manufacturing						
Computer and business machines	16	808	n.p.	212.4	45.4	262.1
Telecommunication, broadcasting and transceiving equipment	-	-	-	-	-	-
Electronic equipment n.e.c.	301	8,027	31.1	1,948.4	361.1	558.1
Electric cable and wire	33	2,461	n.p.	939.2	134.9	241.8
Total Manufacturing	**351**	**11,296**	**109.5**	**3,099.9**	**541.4**	**1,062.0**
Wholesale trade						
Computers	-	-	-	-	-	-
Business machines and electrical and electronic equipment n.e.c.	1,914	26,744	634.9	9,174.2	1,088.7	1,660.4
Total Wholesale trade	**1,914**	**26,744**	**634.9**	**9,174.2**	**1,088.7**	**1,660.4**
Telecommunication services	-	-	-	-	-	-
Computer services	-	-	-	-	-	-
Total	**2,264**	**38,040**	**744.5**	**12,274.0**	**1,630.1**	**2,722.3**

n.p. = not published; n.e.c. = not elsewhere classified;
Source: ABS AusStats 2001.

However, Australia is one of the heaviest consumers and adopters of ICT in the world (examples see Table 1.2). The Economist Intelligence Unit/Pyramid Research in evaluating the E-business Readiness of over 60 countries ranks Australia 6th and 2nd in 2002 and 2001 respectively (EIU 2001, 2002). The readiness ranking is based on 6 categories of factors: connectivity; business environment; e-commerce consumer and business adoption; legal and regulatory environment; supporting e-service; social and cultural infrastructure. The index used by the Australia's own National Office for Information Economy (NOIE) places Australia 3rd behind the US and Sweden[13].

Table 1.2: Summary of Australia's status in ICT penetration and usage relative to other countries.

	Aust ranks	Highest Ranked
% of households with a fixed telephone line	7th	Norway , Sweden
% of households with more than one fixed telephone line	6th	US
% of persons 16 years and over with use of a mobile phone	8th	Hong Kong
% of households which own / lease a PC	2nd	South Korea
% of households connected to the Internet	7th	Hong Kong, Sweden
Internet connection speeds	9th	South Korea

[13] http://www.noie.gov.au/projects/framework/Progress/ie_stats/CSOP_April2002/index.htm

% of persons 2 years and over with Internet access via a home PC	8th	Sweden
% of persons 16 years and over with Internet access from any location	5th	Sweden
% of persons 16 years and over with Internet access at home	8th	Sweden
% of persons 16 years and over with Internet access at work	4th	Sweden
% of persons 16 years and over with Internet access actually using the Internet	6th	Sweden
Equity of access (lowest difference) between males and females for persons 16 years and over	1st	Australia
Equity of access (lowest difference) between age groups for persons 16 years and over	1st	Australia
Number of persons 16 years and over with Internet access per ISP	1st	Australia
Number of secure servers per 100,000 persons 16 years and over with Internet access	2nd	US
Price of 40 hours of Internet use at peak times	3rd	US
Charges for a basket of national leased lines of 2 megabits per second	10th	Sweden
Average number of Internet sessions	9th	South Korea
Average hours online per month	7th	South Korea
% of persons (people with Internet access and browsers) 16 years and over purchasing online	5th & 8th	US
B2C as a % of GDP	6th	US
B2B as % of GDP	4th	US
Peak penetration of online government services	3rd	US

Source: NOIE's State of Play – April 2002 (NOIE 2002).

Many other key statistics on ICT usage and diffusion released by the Australian Bureau of Statistics supports the view that ICT is widely adopted and diffused in Australia. Some of these statistics include:

- Businesses using ICT:
    - 84% were using computers (up from 76% in June 2000)
    - 69% had Internet access (up from 56%)
    - 22% had a web presence (up from 16%)
    - 20% were purchasing via the Internet (up from 10% in 1999-2000)
    - 9% were selling via the Internet (up from 6% in 1999-2000)
- ICT in Government (in 2001):
    - Total IT&T expenditure were $4.3 billion (5% of total government operating expenditure).
    - 47% of the IT&T expenditure were from federal government, 45% from state/territories, and 8% from local governments.
    - IT employees accounted for 2% of government employment.
- Farm use of ICT (in 2001):
    - Total IT&T expenditure were $4.3 billion (5% of total government operating expenditure).
    - 47% of the IT&T expenditure were from federal government, 45% from state/territories, and 8% from local governments.
    - IT employees accounted for 2% of government employment.
- ICT R&D
    - The business sector is the biggest contributor to ICT R&D expenditure.
    - In 1999-2000, total business sector R&D expenditure on ICT were $1.4 billion, mostly in *Computer Software* and *Communications Technologies*.

- IN 1999-2000, the section of the ICT industry investing most in R&D is the *Computer Consultancy Services* ($489 million of the $1.2 billion by all specialist ICT industry sections).

Further statistics on R&D by higher education, government and businesses can be found in Chapter 5.

Refer to links in Appendix A for further details of key measurements of the ICT in Australia, including those from the ABS.

1.4 ICT, Growth and Productivity

ICT as a production sector internationally is still relatively small. In spite of that, its impact has been substantial. It is well established that ICT can be a strong driver for economic growth - for example see McKinsey (2001) and Roeger (2001) for the U.S.; Daveri (2000) and Van Ark (2000) for Europe; Productivity Commission (PC 1999), Parham (2002a, 2002b), Simon and Walrdrop (2002) for Australia. ICT can contribute either directly through investment increase in the technologies themselves, or by contributing to growth in other measured outputs. One of the most important, and most studied, aspects of economic growth due to ICT is *productivity* (and *labour productivity* in particular). In the last half decade going into 2000, Australia and the US[14] experienced a significant surge in productivity[15] (0.5% of GDP in the US, and 1% of GDP in Australia). This productivity surge was also found in countries like Ireland and Finland, but not in other major economies like Japan and Europe in general (Schreyer 2000). The most visible candidate for the driver of this productivity surge was ICT. Studies show that IT and ICT spending are strongly linked to that productivity gain in US (USCEA 2001, Oliner and Sichel 2000) and in Australia (PC, 1999). However, these links between ICT and productivity above are mostly correlational, rather than causal in nature. Most studies found productivity gains in industries with high ICT-adoption, like Finance and distributions channels in wholesale and retail trade, etc (Johnson et al 2000, Pilat and Lee 2001, Parham, Roberts and Sun 2001, Parham 2002a). However, the exact cause-effect relationship is not as obvious.

In analysing what aspects of productivity ICT contributes to, we look at the two components of productivity: capital deepening and multi-factor productivity (MFP). For capital deepening, analysis suggests that the capital increases in ICT have merely replaced other forms of capital, resulting in minimal net capital deepening. In Australia during the last half of the 1990s, the net capital deepening overall have actually decreased by 0.1% of GDP in spite of a massive 0.4% increase in ICT capital (Parham 2001, 2002a, 2002b). The conclusion from this is that ICT's role in capital deepening does not contribute significantly to overall growth.

As for MFP, some commentators (eg. Oliner and Sichel 2000) attribute approximately 0.3% of GDP in MFP acceleration in the US in the second half of the 1990s to manufacturing and production of ICT. However, since Australia has a very minor ICT production sector, it leaves a big question about where its 1.1 percentage point MFP acceleration comes from. A common answer is that ICT adoption has transformed the activities of individuals and businesses, and across multiple

[14] Due to the US's leadership in ICT and its link to their productivity, data from the US is commonly used around the world as a benchmark for productivity gains resulting from ICT.

[15] Although the existence of a productivity surge in Australia in the 1990's is widely accepted, there are commentators who question the positive interpretation commonly used to explain this surge. Eg Quiggin (2001) argues among many things that this surge is only a temporary statistical artefact due to unsustainable factors like increased work intensity.

industries (PC 1999, Parham et al 2001). These effects have been found in other countries as well (Bresnahan et al 2002, Jorgenson and Stiroh 2000, Dumagan and Gill 2002). Many believe it is these transformations that will bring the most benefits to economies (APEC 2001, Simon and Wardrop 2002, Parham 2002a). But for these transformations to happen, it will take time for the technologies to be diffused and for firms to undergo organisational change and worker up-skilling to adjust to them. Some commentators believe that the real economic effects of ICT are to emerge in the near future (eg. Gruen 2001).

There are also other non-ICT factors that many believe contribute to the productivity surge, including education and skill (Barnes and Kennard 2002), sharper competition, trade and investment openness, and microeconomic reform (PC 1999, Pilat and Lee 2001, Parham et al 2001, Parham 2002a,b).

See sections 2.5 and 2.7 for a review on the impact of knowledge as presented in this section on national policy recommendations.

1.5 Current Downturn in the ICT Sector

The current downturn in the ICT sector has been very visible in the media. There has been extensive news coverage of declines in technology stocks, the dot-com bust and large-scale job cuts[16]. In spite of this, many still believe we are just as actively shifting towards a knowledge-based economy (Price and McKittrick 2002, section III in APEC 2001). All industries, including the ones classified as "old economy", are being transformed. The transformations are the result of networked information, greater transparency, and enhanced efficiency through business-to-business transactions. All these came about partly due to the diffusion, adoption and integration of new technologies.

However, what the current downturn shows is that conventional business cycles and inflation are still very much a part of the economy. The over-optimistic belief that the new economy can eliminate business cycles and inflation was misguided. The failures of many technology firms also demonstrate that pursuing unreasonable rates of profitability and growth can come at a huge cost.

The OECD *Information Technology Outlook 2002* report (OECD 2002, page 25) attributes the current industry slump to: firms' over-investment; correction in high-technology stocks; saturation in ICT markets; lower supply-side inventory buffers; and accelerated write-offs on the demand-side. As expected, it is cautious in predicting an upturn, but is optimistic for the near-term and noting that many of the factors causing the downturn are reaching the end of their adjustments[17]. The current consensus among global community is one of cautious optimism for a slow recovery in the general economy within the next year[18].

Another very important fact also arises out of the turmoil in the last few years: the nature of the ICT field can turn quite dramatically. Just as the rate of growth and the

[16] An informal count by this author on articles appearing in the online IT section of *The Australian* newspaper showed that headlines of job cuts appeared on average once every two days in the two months following September 11 2001. Some of the job cuts were also very substantial (eg. 20 000 at Nortel, 10 000 at Alcatel, 9400 at Motorola, etc).

[17] It is important to consider that the report analyses the environment only up to early 2002, and therefore is not able to take into account very recent developments (such as the accounting scandals and the prolonged and continued decline in stock exchange equity prices).

[18] Example, see recent summary of global economy in article "The Unfinished Recession", *The Economist*, 28th Sep 2002, and address by RBA's AssistantGovernor in "The Global Economic Scene", *Reserve Bank of Australia Bulletin*, September 2002.

ubiquitous impact of ICT in the 1990s were was unexpected, so were the timing and the extent of the downturn. The act of prediction in disruptive technologies like ICT is fraught with danger. This is especially important when most of the data we currently have on the trends in this field come from over one-half to two years ago (before 2001). This lag in trends data is common in any field. We need to take care in using such data to predict into the future.

1.6 Key Findings

1. ICT plays a critical role in the knowledge-based economy and society, but that role is multi-faceted and complex. Effective long-term planning for sustainable ICT developments requires in-depth understanding of ICT from many perspectives.

2. There are many different definitions of 'ICT', each with its unique purpose. As the use of the term is yet to reach full maturity, the definitions will likely be further modified. By keeping abreast of key national and international developments in such definitions, we can gain insight into critical components of this field.

3. The current consensus view for the sector is for a slow recovery in the near future. But the upheaval in the last decade demonstrates the need for structures and processes that are relatively adaptable to cyclic fluctuations. Such adaptable structures will be crucial as we face the uncertainties still present in this sector.

4. Most data currently available on this field are pre-2001. We need to take care in using such data to predict into the future.

2. Government Policies and Initiatives in ICT

2.1 Major Government Policies and Programmes

The current Australian Commonwealth Government's vision for ICT is based on *The Strategic Framework for the Information Economy*[19], released in January 1999. The document sets the national direction and goals for Australia's Information Economy.

In January 2001, the Commonwealth Government also released its innovation statement *Backing Australia's Ability*. The statement covers a range of initiatives to promote innovation through 3 key areas: 1) research and development, 2) commercialisation of products, and 3) skills development and retention. The initiatives in *Backing Australia's Ability* with specific references to ICT included the following over the subsequent five years:

- $176 million for Centres of Excellence in ICT and Biotechnology;
- $100 million for an Innovation Access Program, to enhance firms' access to new technologies, and accelerate the use of e-commerce business solutions, especially for small and medium enterprises;
- $151 million for an additional 2 000 university places each year, with priority given to ICT, mathematics and science;
- $34 million to assist in developing ICT tools and on-line curriculum for schools.

The *Backing Australia's Ability* statement also mentions the following, without specific funding promises:

- Adjustments to immigration arrangements to attract ICT-skilled migrants;
- Enhanced equity and affordability of on-line access, to promote ICT usage among businesses and consumers.

There are also other initiatives dealing with research project and infrastructure funding, commercialisation, tax concessions, intellectual property protection, postgraduate fellowships and study loans, etc, that are very relevant to ICT developments as well[20].

Subsequent to the January 2001 statement, a selection process was undertaken to establish and operate the $129.5 million national ICT Centre of Excellence. In May 2002, the National ICT Australia (NICTA)[21] consortium was announced as the winner to the bid. Refer to section 5.4 for an overview of current developments in research aspects of this Centre of Excellence.

The Government also supports another important innovation programme called the Cooperative Research Centres (CRC)[22] programme. It brings together universities, government laboratories, and public and private organizations, in long-term collaborative R&D and education activities. Again, refer to section 5.5 for an overview of current developments in CRCs.

[19] http://www.noie.gov.au/projects/framework/index.htm
[20] For the full set of initiatives, refer to web site http://backingaus.innovation.gov.au/.
[21] http://nicta.com.au/
[22] http://www.crc.gov.au/default.htm

2.2 ICT Education and Training Action Plans

The Governments' education and training policies and directions in ICT are formulated under the action plan *Learning for the Knowledge Society* (DETYA 2000). The action plan is in response to the *Strategic Framework for the Information Economy*, in particular to strategic priority 2: "*deliver the skills and education Australians need to participate in the information economy*". Under *Learning for the Knowledge Society* action plan, the three major education and training sectors formulate their own individual action plans[23]:

- *Learning in an Online World* – the School Education Action Plan, under the Department of Education, Science and Training (DEST).
- *Flexible Learning for the Information Economy* - Vocational Education and Training (VET) Action Plan, under the Australian National Training Authority (ANTA).
- *The Way Forward* - Higher Education Action Plan, under the Australian Vice-Chancellors' Committee (AVCC).

The *Learning for the Knowledge Society* action plan is developed in concert with the *National Goals for Schooling in the Twenty-first Century* (MCEETYA 2000) for pre-tertiary schooling, and the *Australian Flexible Learning Framework* for vocational training. See chapters 6 and 7 for ICT developments in these two areas.

Another important initiative in ICT skilling is the establishment of the IT Skills Hub <http://www.itskillshub.com.au/>. The IT Skills Hub was established with the financial support of DEST and the National Office for Information Economy (NOIE). It serves as the information and resource focal point for all key stakeholders (students, educators, employers and employees) in ICT skills.

There are many programmes in ICT education and skills training, but one thing that is still lacking is a coherent vision linking the different stakeholders. For example, the difference in roles between higher education and vocational education and training is not clear (IT&Titab 2002, Finding 10).

2.3 Other Commonweath Programmes

The Commonwealth Government also supplies the following programmes in promoting ICT developments, mainly directed towards industry and private sector[24]:

R&D:

- R&D Start and R&D Tax Concession through AusIndustry

Industry Development:

- Strategic Partnership Industry Development Agreements (SPIDA) programme
- Electronic Industry Action Agenda

Venture Finance (through AusIndustry[10]):

- Commercialising Emerging Technologies (COMET)
- Innovation Investment Fund (IIF)
- Pooled Development Funds (PDF)
- Pre-Seed Fund
- Venture Awareness

Technology diffusion to individuals and households

[23] See http://www.dest.gov.au/schools/publications/2000/learning.htm for details.
[24] Summarised from Australian Government's response to OECD IT Outlook 2002 document, available http://www.oecd.org/pdf/M00033000/M00033677.pdf

- The Tech Trek
- Internet Assistance Programme
- Networking the Nation (NTN)

Technology diffusion to businesses:
- National Communications Fund (NCF)
- Internet Assistance Programme
- Software Engineering Quality Centres (SEQC) programme

Small and Medium-sized Enterprises (SMEs):
- Building on IT Strengths (BITS) Incubator Programme

Demonstration projects:
- Trials of Innovative Government Electronic Regional Services (TIGERS) project
- Building on IT Strengths (BITS) Advanced Networks Programme (ANP)

Government Services:
- Government Online strategy
- Business Entry Point (BEP)

Business environment:
- e-Procurement strategy
- Copyright Ammendment (Digital Agenda) Act 2000

Trade and foreign investments:
- Invest Australia
- Export Market Development Grants (EMDG)
- Major Project Facilitation (MPF)
- Regional Headquarters Programme
- Feasibility Study Fund
- Strategic Investment Coordination

2.4 Australian Oversight and Regulatory Bodies

Currently, the Commonwealth Government's initiatives in ICT are directed by the following bodies:
- National Office for Information Economy (NOIE) <http://www.noie.gov.au/> – the leading national body for Information Economy issues
- Australian Communications Authority <http://www.aca.gov.au> - responsible for regulating telecommunications and radiocommunications.
- Department of Communications, IT and the Arts (DCITA) <http://www.dcita.gov.au> – Ministerial department regulating all ICT areas.
- Department of Foreign Affairs and Trade (DFAT) Information Industries and Online Trade (IIT) section <http://www.dfat.gov.au/ma/infotech/> - addresses market access issues in ICT industries.

Current ministerial councils responsible for oversight and coordination of ICT activities include:
- Online Council (OC) <http://www.noie.gov.au/oc/>
- Ministerial Council for the Information Economy (MCIE) <http://www.noie.gov.au/projects/framework/Coordination/MCIE.htm>

Other important governmental bodies with activities impacting ICT include:

- AusIndustry <http://www.ausindustry.gov.au/> - in the Department of Industry, Tourism and Resources (DITR), providing incentives, products and services to foster innovation and competitiveness in Australian industries, including ICT-related industries.
- Austrade <http://www.austrade.gov.au/home/> - the Australian Trade Commission, facilitating and advising on export and foreign investments.
- Department of Education, Science and Training (DEST) <http://www.dest.gov.au/ > – primary, secondary and tertiary education and training in ICT areas. Works with state and territory governments in implementing the education system.
- Department for Employment, Workplace Relations (DEWR) <http://www.dewr.gov.au/ > – ICT employment information and issues.
- Australian Competition and Consumer Commission <http://www.accc.gov.au/> - responsible for consumer protection and administering the national competition policies, including to the ICT industry.
- Commonwealth Science and Industry Research Organisation (CSIRO) <http://www.csiro.au> - an agency constituted to conduct research in fields of science and industry, including ICT.

The following are important non-governmental industry bodies in ICT:

- Australian Information Industry Association (AIIA) <http://www.aiia.com.au/> – collects and distributes statistics and promotes ICT industries.
- Australian Communication Industry Forum (ACIF) <http://www.acif.org.au/> - established by the telecommunications industry to self-regulate the industry and promote both the long term interests of end-users and the efficiency and international competitiveness of the Australian communications industry.
- Australian Computer Society (ACS) <http://www.acs.org.au/> – coordinates activities for computing professionals.
- Telecommunications Industry Ombudsman (TIO) <http://www.tio.com.au/> - industry-based service to help resolve disputes between consumers and telecommunications companies.
- Standards Australia <http://www.standards.com.au> - publishes standards relevant to ICT products, services and processes. It represents Australia in two key international standards bodies: the International Standards Organisation (ISO) and the International Electro-technical Commission (IEC).

2.5 Major Reviews and Policy Recommendations

There have been some very recent reports reviewing the state of ICT and ICT skills in Australia (eg. see ACS 2002a). Many of the reviews concluded that we need a holistic approach to this area. Economic performance requires full integration in all areas of ICT usage, manufacturing, services, and research. Skills in all these areas are also required to progress.

An area that many of the reviews have addressed heavily is the ICT trade imbalance. The uneven production/usage in Australia results in a balance of trade in ICT goods and services heavily biased towards imports (Houghton 2001, 2002). The Australian Computer Society (ACS, 2002a), the Prime Minister's Science, Engineering and Innovation Council (PMSEIC, 2000), and Australia's Chief Scientist (Batterham, 2000) have been strong voices in advocating the development of a strong ICT production section to address this trade imbalance. The arguments presented by these quarters are principally based on the belief that high ICT-

adoption is not sustainable in the long-term without a viable domestic ICT-production sector.

There are however, arguments from very other quarters that policy direction focussing on ICT-production is flawed. Experiences show that of the setting up and maintaining a successful ICT-production sector involves very high cost (USCEA, 2001) and is not within the capacity of most national economies. It is also very difficult to achieve an economy of scale to benefit from such a sector. Then there is compelling evidence from several countries that high MFP growth does not require a large ICT-production sector. The few other countries that do have a large ICT sector have not been among the high growth countries of the 1990s. For further information on this issue, and references to other works on this matter, refer to section 1.4.

Because of the reasons above, Dean Parham (Parham 2001, 2002a, 200b), Assistant Commissioner of the Productivity Commission has consistently argued the importance of developments in environmental factors such as macro-economic policies and trade openness, rather than concentrating only on ICT manufacturing and service. OECD has also maintained a similar line:

> "*In sum, governments should resist believing that deliberately developing an ICT manufacturing sector would be a sure route to improved economic growth*." (OECD 2001a, page 38).

2.6 State and Territory Responses

Australian States and Territories have had very active responses to the challenges posed by the transition to a knowledge-based economy. In particular, New South Wales, Victoria, Queensland and Tasmania have major programmes focussed on the ICT aspects.

Below are links to main programmes and State/Territory government bodies responsible for the development of ICT.

- New South Wales: Office of Information Technology <http://www.oit.nsw.gov.au/>
- Victoria: Multimedia Victoria <http://www.mmv.vic.gov.au/>
- Queensland: Information Industries Bureau <http://www.iie.qld.gov.au/comminfo/default.asp>
- Western Australia: Department of Industry and Technology <http://www.indtech.wa.gov.au/> and Industry and Technology Advisory Council <http://www.wa.gov.au/tiac/>
- South Australia: Information Economy Policy Office <http://www.iepo.sa.gov.au/>
- Tasmania: Intelligent Island <http://www.intelligentadvantage.net.au>
- Northern Territory: Department of Corporate and Information Services <http://www.nt.gov.au/dcis/>
- Australian Capital Territory: Chief Minister's Department <http://www.cmd.act.gov.au/>

2.7 International Responses

Most developed countries around the world have broad policy frameworks and initiatives to encourage the development, diffusion and use of ICT. These frameworks generally cover many areas of their economy and society.

The primary focus of most frameworks is to develop a broad coherent vision for ICT for the respective countries. The visions generally address issues of economic and social benefits and universal access for all. More specific areas covered by national policies include technology developments and diffusion, economy and regulatory environment, and globalisation and digital-divide issues. Table 2.1 gives examples of the major areas covered.

Most international policy recommendations promote the approach of broad policy coverage and programmes, rather than the production sector focus of the mid-1990s. There is an increased recognition of the complex interplay between many factors in reaping the benefits of ICTs. See section 1.4 for related discussions on this issue.

OECD (2001a, page 39) makes the following recommendations in regard to the development of ICT within a knowledge-based economy:

- Focus policy efforts on increasing the use of new technology
- Increase competition and continue with regulatory reform in the telecommunications industry to enhance the uptake of ICT.
- Ensure sufficient competition in hardware and software to lower costs.
- Build confidence in the use of ICT for business and consumers.
- Make e-government a priority.

The point of these recommendations is to have a broad vision on the development of ICT. As stated in its *The New Economy Beyond the Hype* report:

> "*… to have any chance of succeeding in ICT, innovation, human capital and firm creation, governments must ensure that the fundamentals – macroeconomic stability, openness and competition, as well as economic and social institutions – are working properly.*" (OECD 2001a, page 24-25)

APEC draws a similar conclusion in its *New Economy and APEC* report:

> "*… the Report concludes that while understandable given the hype over high technology manufacturing in recent years, the strategy of focusing of technology indicators, instead of policy indicators, as guideposts to the New Economy is misleading and possibly dangerous. Numerous examples, especially in the case studies, serve to demonstrate the consequences of over-reliance on technology goals to the exclusion of understanding the causal role of structural policy reform.*" (APEC 2001, page 4)

Table 2.1: Areas of Policy Emphasis in OECD Countries

	Total number of country responses
General policies	**20**
Policy environment and broad policy vision	20
Technology development	**20**
R&D programmes	19

Development of ICTs for government use	12
Government procurement	11
Venture finance	9
Technology Diffusion	**21**
Diffusion to individuals and households	20
Diffusion to businesses	20
Government services online	19
SMEs	18
Programmes to demonstrate benefits of IT use	17
IT environment	**20**
Electronic settlement, authentication and security	19
Intellectual property rights	14
Standards	11
Globalisation	**18**
International co-operation	17
Trade and foreign direct investment	8

Note: This table is summarised from the 21 country responses received by OECD for its IT Outlook Policy Questionnaire. The table counts the number of countries that has policy responses in the different areas.
Source: OECD (2002).

2.8 Key Findings

1. The Australian Federal Government's policy vision in ICT development is underpinned by the *The Strategic Framework for the Information Economy,* released in 1999, and recently the *Backing Australia's Ability* innovation statement in 2001. The framework and statement cover many areas of policies, from education to R&D to industry development. Further developments would likely be within this framework, or a variant of it.

2. Long-term policy developments in ICT require in-depth understanding of different aspects of the ICT field. In particular, current knowledge points to some key areas:

   - Effective planning and adoption of ICT at the firm and organisational level
   - Competition, trade and investment openness
   - Continuation in the macro-economic reforms started in the 1990s.

3. Some recent reviews of Western Australia's state performance have raised concerns over the state's ability to compete effectively in the knowledge-based economy[25]. Such issues need to be addressed decisively.

[25] We have not reviewed this matter fully in this document due to time constraint. We refer interested readers to recent reports by the Technology and Industry Advisory Council (TIAC 2002a, 2002b) and references thereof.

3. ICT Employment in Australia

3.1 Measuring ICT Employment

There are two ways to measure ICT employment:

- Persons **employed by businesses and organisations** within the ICT sector, and
- Persons **working in an ICT occupations** in different sectors.

As a consistent and universal ICT sector definition is still being developed, these two perspectives of ICT employment are sometimes confused.

In Australia, classification of ICT businesses are done under the Australian New Zealand Standard Industrial Classification (ANZSIC) system (see section 1.2 for overview of ICT sector definition), and the classification of occupations is done under the Australian Standard Classification of Occupations (ASCO).

Under the current ASCO 2nd edition, the two 4-digit code occupations most relevant to ICT-related workers are:

1224 Information Technology Managers
2231 Computing Professionals

There are also numerous other occupational categories in ASCO that involve ICT-related work, but are not classified specifically as ICT professions. This is a significant point because not all higher education graduates from ICT courses end up working in jobs classified under the two ASCO categories above. Therefore, measuring employment in the two ASCO codes may not accurately reflect the destinations of ICT tertiary graduates.

The Commonwealth Department of Employment and Workplace Relations (DEWR) maintains a list of job specialisations for all occupations. As an indication of the volatility of ICT occupations, DEWR states in their June 2002 Jobs Outlook that *"Over 1500 ICT specialisations are in use in the Australian economy at present – 360 of these are new in the past year, while other ICT skills have become obsolete."* (page 10, DEWR 2002)

3.2 Current Employment

According to the Commonwealth Department for Employment and Workplace Relations June 2002 Job Outlook (DEWR 2002, page 18), there are 225, 800 people employed in *Computing and IT* in Feb 2002. 195, 600 of them are *Computing and IT Professionals*, and 30,200 are in *Computing and IT Support*.

DEWR's current Jobs Outlook web site[26] also states the following about the occupational category *Computing Professionals* (but do not include any indication of how up-to-date the information is):

Occupation Size: 165,200
Weekly Earnings: $1105 (before tax)
Job Prospects: Very Good
Main Employing Industries: Property and Business Services

[26] Refer to http://jobsearch.gov.au/joboutlook/. The statistics as given for *Computing Professionals* category are listed when viewing the details of any of the computing relating jobs descriptions.

Working Full Time: 92.5 %
Main Age Group: 25-34 years (37.7%)
Gender: F 19.9% M 80.1%

Table 1.1 in chapter 1 from ABS survey on the production and distribution of IT&T goods and services by businesses in Australia also has similar figures: there are 238 521 persons working in IT&T specialist businesses in June 2001.

Figure 3.1 and Table 3.1 reiterate the points raised in section 1.3, that ICT usage is diffused over many different industrial areas. ICT-related jobs are not restricted only to core ICT industry alone. The types of work being conducted are also broad and applicable to many different areas. Appendix F presents more comprehensive lists of job descriptions from major ICT job guide sites in Australia and the U.S.

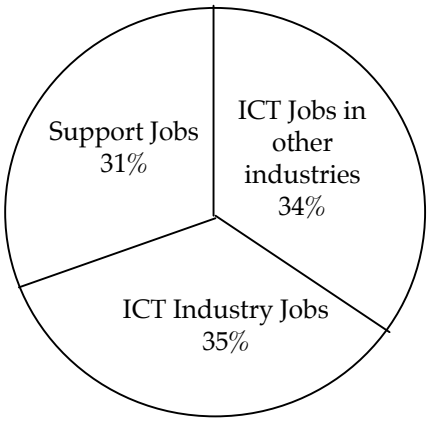

Figure 3.1: Categories of ICT-related employment across all Australian Industries (2001). Source: page 24, IT&Titab (2002).

Table 3.1: Employment by core IT&T Skills Occupation Group in Australia 2000-2002

	2001 Number	2002 Number	% Change
Software developers	**64,200**	**70,300**	**9.5**
• Analysts	39,500	43,600	10.4
• Software engineers	13,700	14,900	8.8
• Testers	11,000	11,800	7.3
Hardware Developers	**8,900**	**10,500**	**18.0**
• Analysts	3,100	3,400	9.7
• Hardware engineers	2,600	3,200	23.1
• Testers	3,200	3,900	21.9
Systems Administration	**29,400**	**32,800**	**11.6**
Managers	**46,100**	**52,900**	**14.8**
• Project managers	24,500	29,000	18.4
• Information managers	11,600	12,700	9.5
• Network managers	10,000	11,200	12.0

Technical advisers/ consultants	**25,900**	**26,000**	**0.4**
Other	**27,700**	**30,900**	**11.6**
Total	**202,200**	**223,400**	**10.5**

Source: Deloitte Touche Tohmatsu Market for Australian IT&T Skills 2000-2002 report to the IT Skills Hub, as given in page 32 in IT&Titab (2002).

Table 3.2: Share of Employment and Businesses in Information Industries in Australia 1998/1999

	% Number of Businesses	% Employment
Communications	5%	35%
Information Services	78%	34%
Wholesale	12%	18%
Content	3%	8%
Manufacturing	2%	5%

Source: Houghton (2001).

Note the difference in ratio between job count in "ICT industry" versus "other industries" in Figure 3.1, and the ratio between persons employed in "IT&T Specialist Businesses" versus "other businesses" in Table 1.1. Part of the discrepancy is due to the two different ways of looking at ICT employment, as mentioned in section 3.1.

3.3 Employment Outlook

The figures as given in Table 3.1 indicate quite vibrant growth in ICT jobs, even going into 2002. Some sections of the Commonwealth Government have also maintained a consistently high assessment of the employment outlook in this area, even in the face of current economy slowdown. For example, the Department for Employment and Workplace Relations Job Outlook publication for June 2002 maintains that in the last five years to Feb 2002, the occupational group *Computing and IT* grew by 51.1%, *Computing and IT Professionals* by 58.6%, and *Computing and IT Support* by 15.6%(page 18, DEWR 2002). It also included *Computing and IT* in the list of occupational groups with the strongest future job growth (ibid. page 12).

There are also other major information sources that take similar optimistic stance. The *Breaking the Skills Barrier* report (CIE 2001) released by the Australian Information Industries Association (AIIA) estimates that Australia face an ICT skills shortfall of 27 500 university graduates over the next five years. *The Australian Information Economy: The Big Picture* report (ACG 2002) released by the National Office for Information Economy estimates 110,000 new jobs can be created between 2002 and 2004-05.

But in the face of this optimistic employment picture painted by the statistics above, there are many trends data that indicate a very soft employment market that will probably persist the short term. For example, the DEWR ICT Vacancy Index, measuring job advertisements in five major Australian ICT online recruiting sites, fell by 4.4% over the four weeks to mid October 2002. The Vacancy Index is down 51.6% over the last year. See figures 3.2 and 3.3.

The Olivier Internet Job Index[27] shows job openings in the IT&T industry fell 11.2% in Septermber 2002, and 58.6% in the 12 months to October 2002.

[27] http://www.olivier.com.au/jobindex.php

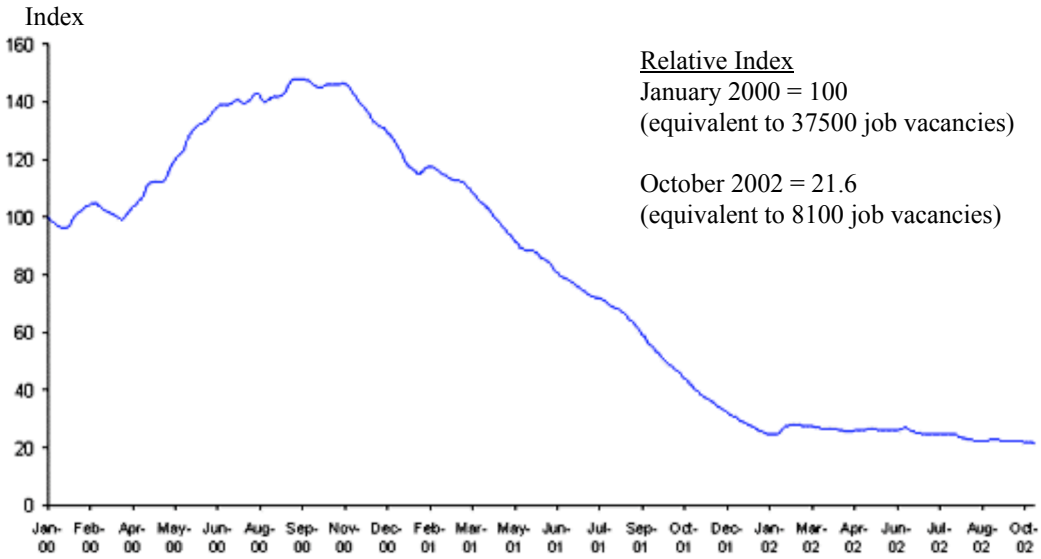

Figure 3.2: DEWR ICT Job Vacancy Index. Source: http://www.workplace.gov.au/Workplace/Publications/Employment

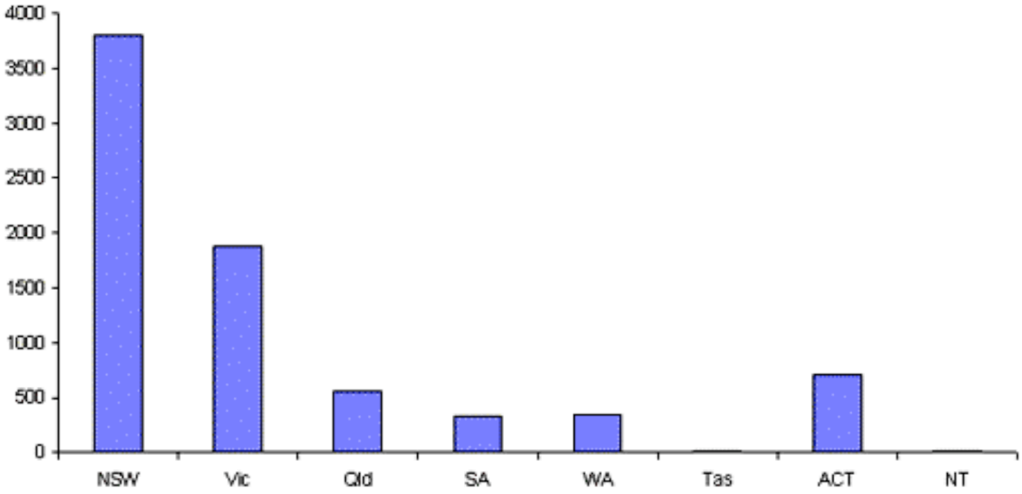

Figure 3.3: DEWR ICT Job Vacancy Index – State by State. Source: http://www.workplace.gov.au/Workplace/Publications/Employment

A few commentators (eg. Braue 2002) have criticised some of the optimistic outlook presented in the face of the current economic climate. Philipson (2002) even suggests some ties between the "myth" of IT personnel shortage with the federal government's immigration policy push.

Faced with confusing and contradictory arguments, the calmest voices seem to be those who caution against knee-jerk reactions. As quoted by John Roberts, Gartner's VP and director of research (Asia Pacific),

> "*Enterprises need to be cautious against embracing the surge of pessimism surrounding IT. It is as unrealistic as the optimism of the past five years*." (Roberts 2002)

3.4 Salaries

The 2002 Australian Computer Society Remuneration Survey showed that average salaries paid to employee IT professionals rose by an average of 4% (4.2% in private sector, and 3.5% in public sector) over the 12 months to May 2002. It is lower on average by comparison to other occupation - the Australian Bureau of Statistics recorded an annual increase of 5.9 per cent in Average Weekly Earnings (AWE) for all occupations for the 12 months to February 2002. Also, we need to view the increase in the context of the 2.9 percent increase in the Consumer Price Index (CPI) in the twelve months to March 2002.

Table 3.3 shows the average salaries for various job categories, as published in the ACS remuneration survey in early 2002. Some commentators (eg. Philipson 2002) suggest that the figures such as the ones in the table are not realistic of the current job market.

Table 3.3: Average Salary Packages in Australia

	Average Packages
Sales & marketing	$160,717
General management	$160,782
Research & development	$119,853
Consulting	$117,994
Project management	$111,498
IT management	$118,590
Project leader	$97,834
Systems management	$85,674
Database administrator	$83,399
Research & teaching	$79,706
Analysis & testing	$77,625
Programmer / analyst	$73,060
Computer support	$68,982
LAN manager	$64,468
Teaching / training only	$61,405

Source: ACS 2002 Remuneration Survey (ACS 2002c)

Table 3.4 presents the salary figures for workers with various skill levels. It shows that in the US at least, there is a very strong correlation between salary levels and the educational attainment of the workers in IT[28].

[28] Other links to US salary surveys can be found at http://jobstar.org/tools/salary/sal-comp.cfm.

Table 3.4: US IT Occupational Employment, By Earnings and Skill Levels, 2000

	Skill Levels*			
Earning Quartiles	**High**	**Moderate**	**Low**	**Total**
Very High >US$39,700	3,240,440	288,670	0	3,529,110
High $25,760-$39,660	522,570	392,630	238,610	1,153,810
Low $18,500-$25,760	0	965,420	1,003,980	1,969,400
Very Low <$18,490	0	0	0	0
Total	3,763,010	1,646,720	1,242,590	6,652,320
Skill shares	56.6%	24.8%	18.7%	
	Earnings Percent Distribution			
Very High >US$39,700	86.1%	17.5%	0.0%	53.1%
High $25,760-$39,660	13.9%	23.8%	19.2%	17.3%
Low $18,500-$25,760	0.0%	58.6%	80.8%	29.6%
Very Low <$18,490	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%

* High: Associate degree, bachelor's degree or work experience plus bachelor's degree or higher
Moderate: long-term on-the-job training, work experience in a related occupation or post-secondary vocational training
Low: short to moderate-term on-the-job training

Source: US Department of Commerce, Economics and Statistics Administration (ESA 2002)

3.5 Areas of Demands for Specific Skills

The Commonwealth Department for Employment and Workplace Relations (DEWR 2002) lists the following as current areas of skill shortages for Australia generally (a full list with breakdown state-by-state as at October 2002 can be found in Appendix G):

- Sybase SQL Server
- C++
- XML
- Progress
- Firewall/Internet Security
- Java (Security and e-commerce)
- SAP
- PeopleSoft
- Siebel
- Satellite Design
- E-Commerce Security (non-programming)
- Security (CISSP)

DEWR also predicts certain areas of skills shortage:

> "*Greater use of the Internet by households for e-commerce, banking and on-line transactions will underpin future demand in Internet-related skills…Future growth in ICT employment is most likely to result from existing businesses using the Internet for marketing their existing goods and services. Consumers are increasingly using the Internet to purchase on-line and this is giving rise to demand for ICT skills in finance, e-commerce and security specialisations.*" (page 10, DEWR 2002)

The Western Australian Information Industry Training Council's IT Future Skills Shortage Survey 2002[29] estimates demand in the following skill areas for the 12 months after April 2002:

- Java
- .Net
- ODBC
- Jscript
- WAP
- Systems analysis
- Bluetooth
- J2EE

[29] Full details available http://www.ieu.com.au/Whats%20New/itfutureskills0302.htm.

- Java Beans
- Oracle 9I
- C++
- OO Analysis
- XML
- Wireless LAN
- Data analysis
- XSL
- Applications development
- Broadband connectivity.

3.6 Employers' Expectations and the Changing Workforce

The traditional approach to curriculum development has been to focus on various aspects of technical education. This approach demonstrates signs of being inadequate for the ICT workforce today. Employers have much higher demand on the recruits and employees.

Career Space is a consortium of eleven major ICT companies (BT, Cisco Systems, IBM Europe, Intel, Microsoft Europe, Nokia, Nortel Networks, Philips Semiconductors, Siemens AG, Telefónica S.A. and Thales) and the European ICT Industry Association (EICTA), formed to promote ICT and to advise the European Commission on narrowing the ICT skill gaps. In their guidelines for University curriculum development[30], they make the following recommendations:

> *"ICT graduates need a solid foundation* ***in technical skills from both the engineering and informatics cultures****, with a particular emphasis on a broad systems perspective. They need training in* ***team working****, with real experience of team projects where several activities are undertaken in parallel. They also need a* ***basic understanding of economics, market and business issue****s.*
>
> *In addition, ICT graduates need to have good personal skills such as* ***problem solving abilities****,* ***awareness of the need for life long learning****,* ***readiness to understand fully the needs of the customer and their project colleagues****, and* ***awareness of cultural differences when acting in a global environment****.*
>
> *The same skill sets are as relevant to ICT professionals working in SME's (Small and Medium Sized enterprises) or in ICT dedicated roles within 'User' companies, as to those working in major ICT companies."*

Employers' demands for such essential 'soft' skills are found in studies into employers' views as well (eg see chapter 2 in CERG 2001).

Braue (2002) argues that there is a conflict between employers looking for specific skills, and Universities teaching fundamental, long-term skills not immediately applicable. He also suggests that soft skills (business acumen, customer-service skills, leadership) are very hard to measure and find. These issues present significant challenges to higher education.

Besides the requirements of employers, the higher education sector is also facing pressures from the changing workforce. The profiles of workers in high technology areas such as ICT seem to have changed quite considerably in the last few decades. The McKinsey Report (as given in Lopez-Bassols 2002) states that the expected duration of graduates in the US staying with their first company for 6 years have dropped from 58% before 1971, to 27% in 1991-1993.

In a study by the Spherion Corporation on the US workforce expectations and values (the Emerging Workforce Study[31]), they found a body of employers and employees called emergent workers/companies who have different values from traditional employers and employees. In particular:

[30] http://www.career-space.com/cdguide/index.htm
[31] http://www4.spherion.com/template/content/trends_study.cfm?menu=trends&headerstyle=1&site=Spherion

- In work environment, emergent employees favour high growth (89%) over predictability (27%).
- Emergent employees prefer creativity (98%) over daily direction (58%).
- Emergent employees tend to believe job security is an employee's responsibility to earn (42%), rather than a company's obligation to provide (15%).
- Emergent employees view job change as positive rather than damaging for their careers.
- Emergent employees believe career advancement should be based on merit rather than tenure.

However, the percentage of emergent versus traditional workforce, as well as where the emergent workforce exists in, is not clear.

Most of the data on the change in workforce profiles come from the US. We can only infer the relevance of that data for the Australian environment.

3.7 Personal and Professional Qualities

Current literature and data lists various personal and professional qualities that IT professionals and employers had indicated as being factors to success. We usually encounter variants of such lists found at careers information sites[32], and in surveys of employers (CERG 2001). Below, we present a summary of all qualities found.

Skills:

- Problem solving
- Analytical thinking
- Interpersonal skills
- Oral communications
- Written communications
- Reporting skills
- Personal organisation and time management
- Administrative and management skills
- Team work
- Leadership skills
- Change management skills

Attributes:

- Creative/Imaginative
- Logical
- Integrity and sense of ethics
- Self-Reliant
- Team-oriented
- Leadership
- Adaptable
- Responsible
- Approachable
- Calm under pressure
- Perseverance
- Professionalism

In the lists above, we have taken liberties in shortening the descriptions from the original sources to basic generic expressions. We have however tried as much as possible to use the same terms as they appeared in the sources.

3.8 Key Findings

1. Statistics suggest that there are approximately 250 000 people Australia-wide working in ICT-related jobs. A majority of them (approximately 200 000) are working in occupations requiring higher education qualifications.

[32] The sites used to derive the list were the ACS' IT Careers Portal <http://www.itcareers.acs.org.au/careers/>, DEWR Job Outlook site <http://jobsearch.gov.au/joboutlook/OccCatSearch.asp>, and the US Bureau of Labor Statistics' Career Guide <http://www.bls.gov/oco/cg/cgs033.htm#occupations>.

2. In spite of some contradictory evidence, the current job market appears to be very weak as the industry undergoes correction in the post-bubble economy. Although long-term trends human resource requirements would probably persist, there is great uncertainty as to the exact nature of any skills-gap or personnel deployment in the near future.
3. Employers in ICT have a higher demand for 'soft' skills and more rounded graduates than before.
4. The workforce in general has a higher demand for more flexible and stimulating work conditions.

4. Tertiary Courses in ICT

4.1 Higher Education in the KBE

The higher education sector plays a key role in the human resourcing needs in ICT. As indicated in Table 3.4, there are many high-level job tasks in ICT that requires tertiary level education to complete. The role of university education is to ensure such educational preparation is available.

But higher education does not serve this role alone. It is widely understood that formal education is only one of the many sources of input into the skills required by a member of the workforce. Other influences in skill development are illustrated in Figure 4.1.

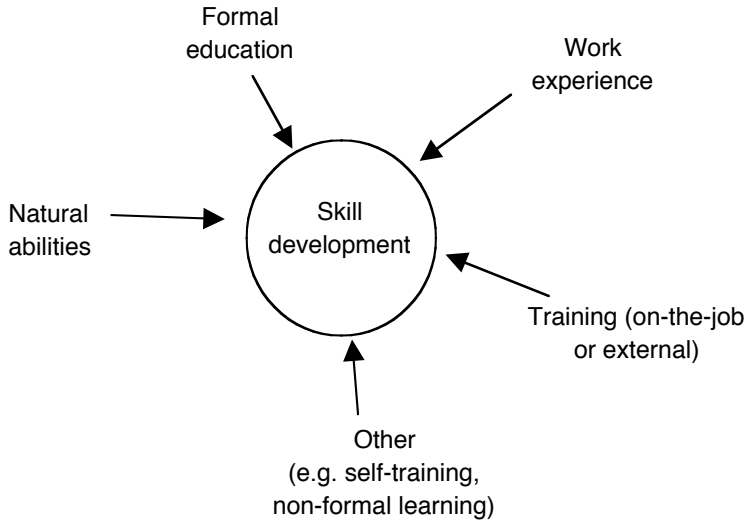

Figure 4.1: How skills are acquired. Source: OECD(2002) page 159.

4.2 ICT Qualifications in Australia

ICT qualifications in Australian higher education exist within the general Australian Qualification Framework (AQF). This framework consists of the Kindergarten to Year 12 (K-12) system, vocational education and training (VET), as well as higher education. Figure 4.2 shows the relationship between the various components.

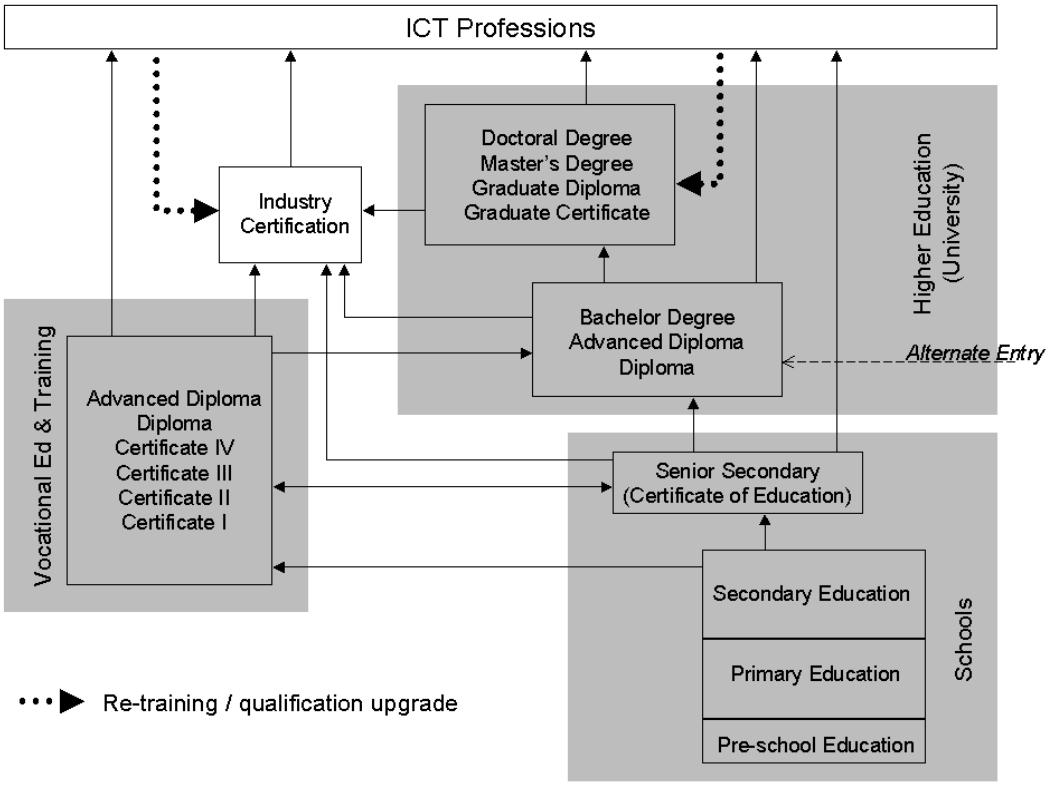

Figure 4.2: Pathways to ICT Qualifications in Australia. The qualification available in the three greyed boxes together forms the current national Australian Qualification Framework (AQF).

Due to the high rate of change in this sector, the re-training/qualification upgrade market has become a significant part of education and training.

4.3 Body of Knowledge

Within any educational area, there needs to be a coherent body of knowledge to guide the development of curriculum. In this regard, a significant international initiative is the *Computing Curricula 2001* (or CC2001) project. This is a joint task force formed in 1998 by the Institute for Electrical and Electronic Engineers' Computer Society (IEEE-CS) and the Association for Computing Machinery (ACM). Its charter was to review the old *Computing Curricula 1991* and develop a new model that is appropriate based on recent developments.

Due to the breath of the field, IEEE-CS and ACM created additional committees to deal produce curricula "volumes" on four specific areas:

1. The volume on *Computer Science* is handled by the CC2001 Joint Task Force itself[33].

2. The volume on *Computer Engineering* is also handled by the CC2001 Joint Task Force[34].

[33] See http://www.computer.org/education/cc2001/final/index.htm.
[34] See http://www.eng.auburn.edu/ece/CCCE/.

3. The volume on *Software Engineering* is handled by the Joint Task Force on Software Engineering Education Project (SWEEP)[35].

4. The volume on *Information Systems* is handled by a joint effort between the ACM, the Association for Information Systems (AIS), and the Association for Information Technology Professionals (AITP)[36].

An approved final draft of the Computer Science volume was released in December 2001 (IEEE-ACM 2001). The other volumes are still work-in-progress. ACM, AIS and AITP also have an extensive history in defining IS body of knowledge, culminating in the currently used IS'97 version, and developments in the new IS2002 model[37]. The volumes on Computer Engineering and Software Engineering are work-in-progress.

Details of IS'97 and the CC2001 Computing Science is given in Appendix D.

In Australia, the Australian Computer Society (ACS) plays an influential role in shaping the developments of computing curricula in higher education. ACS defines a set of *Areas of Knowledge* in Information Technology. ACS' developments follow from some of the work done by ACM and IEEE-CS. While recognising the difficulty in defining what exactly Information Technology is, ACS still mean for the areas of knowledge to be the "*… core Body of Knowledge in Information Technology which* ***all*** *I.T. professionals practising in Information Systems, Computer Science and Computer Systems Engineering should be expected to have.*"[38]

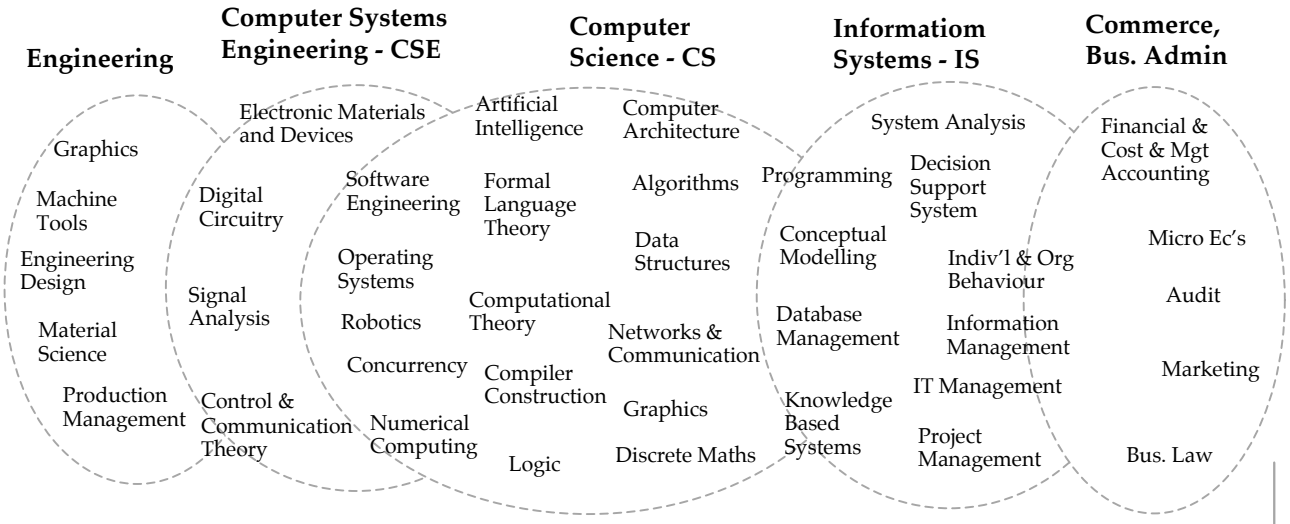

Figure 4.3: ACS' Conceptual Model of I.T. Related Body of Knowledge. Source:
http://www.acs.org.au/static/national/pospaper/attach.htm

The ACS categorises IT-related fields as in Figure 4.3. This categorisation is in keeping with some of the perspectives discussed in section 1.2. It is also in line with the breakdown of the *Information Technology* category under the Australian Standard

[35] See http://sites.computer.org/ccse/.
[36] See http://www.is2000.org/.
[37] See http://192.245.222.212:8009/IS2002Doc/Main_Frame.htm.
[38] Quoted from http://www.acs.org.au/national/pospaper/bokpt1.htm.

Classification of Education (ASCED), used by the Australian Bureau of Statistics (ABS) and the Commonwealth Department for Education, Science and Training (DEST) for higher education statistical collection purposes in Australia (see Appendix D for details on ASCED).

However, the current ACS and ASCED definitions seem to be slightly out-of-date with current international developments in ICT as outlined in section 1.2. In particular, the weaknesses include loose integration between Information Technologies and Communication Technologies (Communication Technologies are classified separate from IT as a field in ASCED), and the lack of references to other electronic content areas such as Digital Media.

There is no question that the body of knowledge constituting ICT, or IT or *computing* has changed and expanded very dramatically in recent years. This is reflected in the comments from the CC2001 task force:

> *"As indicated in our charter, the goal of the CC2001 effort is to revise Computing Curricula 1991 so that it incorporates the developments of the past decade. That task has proved much more daunting than we had originally realized. Computing has changed dramatically over that time in ways that have a profound effect on curriculum design and pedagogy. Moreover, the scope of what we call computing has broadened to the point that it is difficult to define it as a single discipline. Past curriculum reports have attempted to merge such disciplines as computer science, computer engineering, and software engineering into a single report about computing education. While such an approach may have seemed reasonable ten years ago, there is no question that computing in the 21st century encompasses many vital disciplines with their own integrity and pedagogical traditions."*
>
> (page 1, IEEE-ACM 2001)

4.4 ICT Higher Degrees in Australia

This section presents some summaries on current ICT-related degrees offered in the 43 recognised Australian tertiary institutions. The full list of the degrees is given in Appendix J.

The postgraduate degree numbers below only include ones with professional coursework components. Pure research degrees (Master of Philosophy MPhil and Doctor of Philosophy PhD) are not counted. We expect all research universities to offer MPhils and PhDs in this area, but the actual analysis of those numbers is left for a future study.

Joint degrees are not listed if the component degrees are offered as individual degrees.

Number of institutions offering ICT-related degrees:	40
Number of institutions with no ICT-related degrees:	3
Total:	43

Table 4.1: Categories of Current ICT-related Degrees in Australian Higher Education

	Number of degrees
Degree levels:	
Undergraduate:	264
Graduate/Postgraduate Diplomas:	260
Professional Masters:	192
Professional Doctorates:	6
Total:	721
Undergraduate degree types:	
Bachelor of Business/Commerce	48
Bachelor of Engineering	47
Bachelor of Science	36
Bachelor of Information Technology	28
Bachelor of Multimedia	10
Bachelor of Computer Science	9
Bachelor of Arts	7
Bachelor of Electronic Commerce	7
Bachelor of Software Engineering	5
Bachelor of Information Systems	6
Bachelor of Technology	6
Undergraduate degrees with name containing:	
Information Technology	50
Information System	31
E-Commerce/E-Business	27
Computer Science	25
Multimedia/Media	24
Software Engineering	19
Telecommunications	14
Internet	10
Network/Networking	7
Graduate diplomas/certificates with name containing:	
Information Technology	55
Information System	44
E-Commerce/E-Business	33
Computer Science	13
Multimedia/Media	11
Telecommunications	17
Software Engineering	11
Internet	7
Masters degree degrees with name containing:	
Information Technology	52
Information System	30
E-Commerce/E-Business	20
Computer Science	13
Multimedia/Media	13
Telecommunications	8
Software Engineering	6
Internet	5

Source: Murdoch University, summarised from Appendix J.

Degrees with containing field names like *Information Technology*, *Computer Science*, *Information Systems*, *Telecommunications*, and *Software Engineering* are now mainstays in many tertiary institutions. This is reflected in the current Australian Standard Classification of Education (ASCED) as outlined in section 4.3 and Appendix D. Starting from the late 1990s, we have also seen widespread introduction of *Electronic Commerce/Electronic Business* degrees. In the recent few years, institutions have also

started offering *Multimedia* and *Internet/Web* related degrees. We also see the beginnings of some degrees on *Security*.

4.5 Enrolments in ICT Degrees

Table 4.2 is summary information on student enrolments in ICT-related degrees. The data is collated from statistical tables from DEST (2002b) on Australian higher education enrolments 2001. The degrees are grouped under the *Information Technology* in DEST Fields of Education[39].

From Table 4.2, we note that most of the IT students are concentrated in New South Wales, Victoria and Queensland. As expected, this is in line with the distribution of job demands by states, as given in Figure 3.3. We also note that IT as a field of education attracts very low female student participation, but has very high overseas student enrolments.

Table 4.2 also shows that relative to overall enrolments in all courses, IT has a very low female participation. This trend is also true of the Sciences, and Engineering. In contrast, IT has relatively high overseas student participation.

Further details of enrolment numbers nation-wide can be found in Appendix I.

Table 4.2: Enrolments in *Information Technology* Degrees in Australian Higher Education, 2001.

	IT students only	All students
Total students enrolled:	61, 391	726, 418
Number of students in each level of course:		
Doctorate by Research	771	29,259
Doctorate by Coursework	4	815
Master's by Research	210	9,240
Master's by Coursework	7,175	68,514
Other Grad/Postgrad	6,890	47,484
Bachelor's	45,994	543,097
Other award courses	347	17,802
Non-award courses	0	10,207
Percentage overseas students in student body:	32.3%	15.5%
Percentage females in student body:	25.9%	55.0%
Percentage students in each state:		
New South Wales:	25.7%	31.9%
Victoria:	27.8%	26.7%
Queensland:	20.9%	18.7%
Western Australia:	7.3%	9.2%
South Australia:	5.6%	7.0%
Tasmania:	1.2%	1.8%
Northern Territory:	0.5%	0.6%
Australian Capital Territory:	3.2%	2.7%
Multi-state:	0.7%	1.3%

Source: extracted and calculated from DEST (2002b).

In 2001, a new *Field of Education* categorisation was introduced by DEST. This new categorisation contains a new broad category called *Information Technology*. Prior to 2001, ICT fields were merged within other broad field of study categories such as *Science* and *Business, Administration and Economics*. Due to this, it is very problematic to make comparisons using published data on broad fields of study between 2001

[39] The same as ASCED in Appendix D.

and prior years. See Appendix D for a breakdown of areas under DEST's *Information Technology* field of education.

Note that due to the fact that DEST's *Information Technology* category does not include Computer Engineering and Telecommunications areas, enrolments in these areas are not included in the summary counts above. This is in contrast to the previous section on *ICT higher degrees in Australia*, where we included counts on such courses in the ICT area.

4.6 Graduate Outcomes

The Graduate Careers Council of Australia (GCCA) conducts annual surveys of fresh graduates on 1) their satisfaction with their undergraduate experiences, and 2) their employment status. Tables 4.3 and 4.4 present the latest set of data released for the two areas classified under *Information Technology*[40]. The data is for the year 2000 graduates, survey in 2001.

Table 4.3: Course Experience Survey: Year 2000 Graduates Australia-wide

	Total Respondents	Good Teaching %	Total Respondents	Generic Skills %	Total Respondents	Overall Satisfaction %
Computer Science	1056	72	1064	87	1068	90
Information Systems	844	72	850	87	855	89

Source: http://www.dest.gov.au/tenfields/stats/field2.htm (accessed 30th September 2002)

Table 4.4: Graduate Destination Survey - Year 2000 Graduates Australia-wide

	Total Respondents	In FT Emp %	Total Respondents	In FT Study %	Total Respondents	Median Salary $
Computer Science	984	86	1252	18	515	37000
Information Systems	763	86	974	18	429	37000

Source: http://www.dest.gov.au/tenfields/stats/field2.htm (accessed 30th September 2002)

The employment data in table 4.4 would likely not be attained by the current batch of IT graduates (year 2002), based on evidence from section 3.3.

4.7 On-line Education in Australia

Australian higher education institutions have an active history in trialing and using ICT for university learning. The developments were assisted by a significant number of grants by CAUT (Committee for the Advancement of University Teaching) and CUTSD (Committee for University Teaching and Staff Development) which together funded a total of 731 projects to the value of $33 million[41]. The roles formerly under CAUT and CUTSD are currently under the umbrella Australian Universities Teaching Committee (ATUC) project *Information and Communication Technologies and Their Role in Flexible Learning*.

Recently in December 2001, DEST released a report *Universities Online, A Survey of Online Education and Services in Australia* (DEST 2001). The report was on an enquiry

[40] Full descriptions of how the data is collected, and the areas the survey cover, are available at http://www.dest.gov.au/tenfields/stats/default.htm.
[41] Source: http://www.autc.gov.au/pr/flexbriefs.htm

into the ways universities are employing the Internet in teaching and learning and services that support university education. The enquiry found among other things:

- There were 207 fully online courses offered by 23 Australian universities, with 90% of them being at the postgraduate level. Most of these postgraduate online courses were specialised courses rather than generic qualifications.
- Universities reported that 50 704 of their units (54%) have content available on the Web, but most were only using the web as supplements. Only 1.4% of the units were fully online units.
- IT units appear to make the highest use of the Web, compared with other discipline areas; 40.5 per cent of IT units are either fully online or Web-dependent.

An important development in university on-line learning is Open Learning Australia (OLA)[42] programme. Started in 1992. OLA is owned and partnered by seven universities: Curtin University of Technology, Griffith University, Macquarie University, Monash University, RMIT, Swinburne University of Technology and University of South Australia. Qualifications offered at 4 levels: bridging, undergraduate, vocational and postgraduate. Each qualification is made up of units. Units can be studied as stand alone subjects, or can be counted towards a qualification.

Current ICT-related qualifications available under OLA are[43]:

Provider(s)	Qualification
Curtin University of Technology	Bachelor of Arts (Internet Studies)
Edith Cowan University	Graduate Certificate of Information Services Archives & Records Stream
Griffith University	Bachelor of Internet Computing
RMIT University	Bachelor of Applied Science
RMIT University and Australian Computer Society	Graduate Diploma of Information Technology Management
	Master of Information Technology Management
Swinburne University of Technology	Bachelor of Technology
	Graduate Diploma of Business (eBusiness & Communication
Swinburne University, TAFE Division	Certificate II/III Information Technology (Software Applications)

4.8 Industry Certifications

Although there is evidence that industry and vendor-specific certifications plays an important part in this field[44,45], there does not seem to be any objective, reliable

[42] http://www.ola.edu.au/
[43] *Taken from full list of qualifications at* http://www.ola.edu.au/docs/choose/pb_choose_browsequals.html – *accessed 12th October 2002.*
[44] *http://www.gocertify.com/article/certification2001.shtml*
[45] *http://www.prometric.com/ImagineIT/default.htm*

study into their roles and their competitive/complementary relationship to higher education qualifications. There are however some data on the extent of their reach. For example, Table 4.5 shows a count of a number of popular certifications held as of early 2000.

Table 4.5: World-wide commercial IT certifications, early 2000

Certification Name	Number of Certifications
Microsoft Certified Professional (MCP)	457 603
Microsoft Certified Solutions Developer (MCSD)	23 785
Microsoft Certified Systems Engineer (MCSE)	231 180
Other Microsoft Certified Professional Programmes	176 028
Certified Cisco Design Associate (CCDA)	4 000
Other Cisco certifications	31 000
Certified Novell Engineer (CNE)	175 000
Certified Novell Administrator (CNA)	370 000
Other Novell Certifications	18 300
Oracle (all certifications)	24 000
CISSP (Certified Info Systems Security Professional)	1 500
CCA (Citrix Certified Associate)	8 000
A+ (Computer Tech Industry Associate)	180 000
Institute for Certification of Computing Professionals	50 000
Natl. Assoc. of Communication Systems Engineers (all Certif.)	18 000
Others (Baan, Sybase, SAP, Adobe, etc.)	43 778
Total	1 812 174

Source: Reproduced from OECD (2002b).

Note that the number of certifications does not equal the number of people with certifications, as many professionals have more than one certification.

Developments in this area are marked by very high turnovers in terms of certifications in specific areas are offered based on prevalent market conditions. New certifications are created and old certifications are deleted at regular intervals. For example, data in 2001 released by the Foote Partners (http://www.footepartners.com/) shows a shift in bonuses paid from the previously popular systems/network operating system certifications, to the new hot areas of security and database certifications.

There is strong evidence that certifications can provide added value in getting higher salaries[29]. Most of the evidence comes from studies sponsored by the certification vendors. There is also some independent evidence, for example from indices provided by Foote Partners LLC. All the evidence, however, are not unanimous. For example, *Certification and Support Salaries* 2001 report[46] by Association for Support Professionals suggests that the relationship between certified personnel and significantly higher salaries may be only coincidental.

There are also developments from the various vendors and certifying bodies to recognise each other's certifications[47], especially among major certifying bodies such as CompTIA.

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http://mcpmag.com/salarysurveys/default.asp
http://www.informationweek.com/story/IWK20011120S0019
http://www.nwfusion.com/newsletters/careers/2002/01331328.html

[46] Available at http://www.asponline.com/certify.pdf (accessed 4th October 2002).

[47] http://www.gocertify.com/article/certification2001_2.shtml#cross

4.9 Key Findings

1. There are over 700 different ICT-related degrees offered in the 43 Australia higher education institutions. They range from associate diploma to doctorate levels. There are degrees of many types from many different faculties, and they cover a broad range of fields.

2. There are approximately 60 000 students enrolled in *Information Technology* courses in Australian higher education. That represents approximately 8.5% of all enrolments. The *Information Technology* field of education includes *Computer Science* and *Information Systems*. Due to classification, other ICT-related courses such as Telecommunications are grouped in a separate field of education, and the number of enrolled students for them is not as readily available.

3. Information Technology courses have very low female participation. This can be a large potential market to tap into, possibly through projecting the image of courses more in line with areas that do attract normal female participation, such as Humanities, the Arts, and Business.

4. Besides gender, residency status and location, there is very little published data on market segmentation of ICT-enrolled students, and potential students.

5. Information Technology courses in Australia attracts high overseas student participation. Universities should continue to develop courses and marketing to sustain this trend.

6. There are very heavy developments toward on-line education. Pressures for flexible learning will likely see such developments continue into the future. Full e-Learning paradigms are still to be fully explored, and can potentially offer substantial teaching and learning benefits.

7. Evidence collected in this study does not provide conclusive decisions on the role of industry certifications, and their relationship to higher education courses. Further studies are required to gain a full understanding.

5. ICT Research and Development in Australian Higher Education

5.1 Higher Education Research and Development

An important part of higher education's contribution to the KBE is in research and development (R&D). As indicated in section 1.1, an innovation system is a key part of a KBE, and innovation requires an active R&D sector. ICT education should be tightly integrated with R&D within the University's operations. As concluded by the Western Australian Technology and Industry Advisory Council's report *The Organisation of Knowledge: Optimising the Role of Universities in a Western Australian 'Knowledge Hub'*:

> *"Collaboration in graduate training and research rather than teaching programs provides the platform for developing international knowledge hubs. If these areas are functioning effectively undergraduate programs tend to follow,"*
>
> (page ii, TIAC 2002b)

5.2 Measuring R&D

The Australian Bureau of Statistics (ABS) current R&D data collection uses the Research Fields, Courses and Disciplines (RFCD) classification under the Australian Standard Research Classification (ASRC). The ABS has stated that this new classification will also be adopted for future surveys of the business, government, private non-profit and higher education sectors.

The relevant ICT fields of research in RFCD are mainly in subdivision 280000 *Information, computing and communication sciences*. Other relevant subdivisions are 291600 *Computer hardware* and 291700 *Communications technologies*. See Appendix D for details of subdivision 280000 in RFCD.

Data collection for R&D undertaken by the ICT industry sector follows the Australian New Zealand Standard Industrial Classifications (ANZSIC) to define individual ICT component industries. For details of the ANZSIC classes used in defining the ICT sector, refer to section 1.2 under *Australian Bureau of Statistics*.

5.3 R&D Expenditures and Areas of Research

Table 5.1-5.3 shows the R&D expenditures for 1998-2000, as released by the Australian Bureau of Statistics. The statistics are activities split into four broad institutional sectors: Business, Government, Higher Education, and Private Non-Profit.

R&D expenditure in ICT disciplines was $1.6 billion during 1998-99, accounting for 18.5% of total R&D expenditure of $8.9 billion. The Business sector dominated ICT R&D, accounting for 84% of the total. The Higher Education sector only accounted for 8% of the same total.

Although ICT R&D expenditure increased between 1996-97 and 1998-99, it did not quite keep pace with the growth in GDP. In 1998-99, ICT R&D expenditure accounted for 0.28% of GDP, compared with 0.29% in 1996-97.

ICT R&D was a significant R&D activity of the Business sector, making up 34% of total R&D expenditure by that sector in 1998-99. In contrast, ICT R&D only

accounted for 6% and 5% respectively of total R&D expenditure by the Government and Higher education sectors in 1998-99.

The three biggest areas of ICT R&D are *Computer Software* (37%), *Communication Technologies* (30%), and *Information Systems and Technologies* (20%). However, in Higher Education, *Information Systems and Technologies* has the highest share.

Table 5.1: R&D Expenditure in ICT Fields of Research

	Proportion of Sector R&D expenditure		Proportion of GDP	
Sector	**1996-97** %	**1998-99** %	**1996-97** %	**1998-99** %
Business	28.9	34.2	0.23	0.23
Government	8.6	5.7	0.03	0.02
Higher education(a)	6.0	5.3	0.03	0.02
Private non-profit	0.4	0.3	0.00	0.00
Total	**17.5**	**18.5**	**0.29**	**0.28**

(a) Data for the calendar year ending within the financial year shown.
Source: Reproduced from ABS (2002a)

Table 5.2: R&D in ICT Fields of Research, By Field - 1996-97 and 1998-99

	Expenditure		Human resources	
Field of research	**1996-97 $m**	**1998-99 $m**	**1996-97 person years**	**1998-99 person years**
Information systems and technologies	357.0	326.8	3,805	2,970
Computer hardware	55.9	55.7	563	497
Computer software	504.7	617.9	4,974	5,813
Communication technologies	426.1	491.9	3,214	2,278
Other information, computer and communication technologies	198.9	157.1	1,466	1,296
Total ICT fields	**1,542.6**	**1,649.4**	**14,022**	**12,854**

Source: Reproduced from ABS (2002a)

Table 5.3: R&D in ICT Fields of Research, By Sector - 1998-99

Field of research	Business $m	Government $m	Higher education* $m	Private non-profit $m	Total $m
Information systems and technologies	216.8	54.7	55.2	-	326.8
Computer hardware	48.5	2.3	5.0	-	55.7
Computer software	582.2	13.2	22.5	-	617.9
Communication technologies	439.9	17.3	34.6	-	491.9
Other information, computer and communication technologies	105.2	29.5	21.9	0.5	157.1
Total ICT fields	**1,392.6**	**117.1**	**139.2**	**0.5**	**1,649.4**

* Data for the calendar year ending within the financial year shown.
Source: Reproduced from ABS (2002a)

Tables 5.4 and 5.5 shows the level of R&D activity by component industries within the ICT sector (ICT sector as defined in section 1.2). During 1999-2000, expenditure on R&D by the ICT sector was $1.2 billion, almost 30% of the total Business sector R&D expenditure. The majority of the expenditure ($959.1 million of the $1.2 billion, or 79%) was in ICT fields of research itself, as opposed to other research areas like Physical Sciences.

Table 5.4: R&D BY by the ICT Industries - 1997-98 to 1999-2000

	Expenditure			Human resources		
Industry of business	97-98 $m	98-99 $m	99-00 $m	97-98 person years	98-99 person years	99-00 person years
Recorded media manufacturing and publishing	10.1	9.9	11.1	123	112	139
Professional and scientific equipment manufacturing n.e.c.	53.2	52.8	61.2	527	521	599
Computer and business machine manufacturing	48.8	34.5	39.6	318	246	226
Telecommunication, broadcasting and transceiving equipment manufacturing	185.8	174.4	131.4	947	994	1,032
Electronic equipment manufacturing n.e.c.	112.3	120.1	95.3	897	1,000	903
Electric cable and wire manufacturing	11.9	2.8	5.8	39	25	36
Computer wholesaling	46.2	49.1	65.2	400	415	627
Business machine wholesaling n.e.c.	23.3	34.3	29.3	156	155	141
Electrical and electronic equipment wholesaling n.e.c.	143.6	148.4	144.5	1,072	923	852
Telecommunication services	125.2	196.9	115.3	97	101	77

Data processing services	31.9	21.0	18.4	289	202	167
Information storage and retrieval services	n.p.	3.7	n.p.	n.p.	19	n.p.
Computer maintenance services	n.p.	-	n.p.	n.p.	-	n.p.
Computer consultancy services	334.0	401.0	489.0	3,129	3,690	4,050
Total ICT industries	**1,129.0**	**1,248.8**	**1,208.0**	**8,024**	**8,402**	**8,869**

n.e.c = not elsewhere classified; n.p. = not published
Source: Reproduced from ABS (2002)

Table 5.5: Business Sector R&D Expenditure in ICT Fields of Research, By Field and Industry - 1999-2000

Field of research	ICT industries $m	Finance and insurance industry $m	Technical services industry $m	Industrial machinery and equipment manufacturing industry $m	Other industries $m	Total $m
Information systems	121.7	52.8	n.p.	n.p.	61.0	264.0
Artificial intelligence and signal and image processing	8.4	-	n.p.	n.p.	8.8	19.7
Computer software	404.3	38.8	12.6	22.6	64.0	542.2
Other information, computing and communication sciences	81.9	n.p.	3.9	n.p.	33.5	146.2
Computer hardware	18.7	n.p.	n.p.	4.0	7.1	37.4
Communications technologies	324.2	-	n.p.	n.p.	12.5	356.1
Total ICT fields	**959.1**	**120.2**	**59.2**	**40.1**	**187.0**	**1,365.6**

n.p. = not published
Source: Reproduced from ABS (2002a)

Reports from the Western Australian Technology and Industry Advisory Council (TIAC, 2002b) indicate similar proportions to the tables above for the numbers in Western Australia.

5.4 ICT Centre of Excellence

A very significant development driving the current research in Australia is the formation of the national ICT Centre of Excellence. As part of the federal Coalition government's *Backing Australia's Ability* policy direction[48], $129.5 million was committed over the five years to start and operate this ICT Centre of Excellence. A selection process was announced in 2001, administered by the National Office for Information Economy (NOIE). In May 2002, the National ICT Australia (NICTA)[49] consortium was announced as the winner to the bid.

The NICTA consortium comprises the Australian National University, the University of NSW, the University of Sydney, the NSW Government, and the ACT Government. The firms Bovis Lend Lease. Redfern Photonics and Allen & Buckeridge were supporting organisations. NICTA will establish major research

[48] See section 2.1 for further details of the *Backing Australia's Ability* policy statement.
[49] http://nicta.com.au/

and training nodes in Sydney and Canberra, with plans to establish collaborative research and training arrangements with other universities and research organisations. The consortium estimates that once established, each of the two nodes will accommodate over 100 PhD qualified researchers, plus PhD students, technical and support staff.

At present, the NICTA lists the following research areas as ones it will focus on, covered under five general *themes*:

1. Infrastructure Technologies
    - Embedded, Real-Time and Operating Systems
    - Circuit and System Design
    - Networking and Pervasive Computing
    - Signal Processing in Wireless Communication systems
    - Database and Enterprise Systems
2. Intelligent Systems
    - Statistical Machine Learning and Sensor Signal Processing
    - Symbolic Machine Learning and Knowledge Acquisition
    - Knowledge Representation and Reasoning
    - Autonomous Systems and Sensing Technologies
    - Distributed Intelligence
3. Software Engineering
    - Empirical Software Engineering
    - Programming Paradigms and Development Environments
    - Formal Methods
    - Security and Trust Management
4. Human-Machine Interaction
    - Machines Understanding Humans
    - Humans Understanding Machines
    - Machine Mediated Interaction
5. Foundations
    - Information Theory
    - Systems Engineering and Complex Systems
    - Algorithms and Complexity
    - Logic and Computation
    - Social and Organisational Sciences

Besides research, NICTA also lists commercialisation, research training, and linkage as its three other important sets of core activities. These sets of activities are not reviewed here.

5.5 ICT Co-operative Research Centres (CRCs)

Another important Government initiative is the Cooperative Research Centres (CRC)[50] programme. This is an innovation programme bringing together universities, government laboratories, and public and private organizations, in long-term collaborative R&D and education activities. There are currently seven CRCs in ICT:

- Australian Photonics CRC
- Australian Telecommunications CRC
- CRC for Enterprise Distributed Systems Technology
- CRC for Satellite Systems

[50] http://www.crc.gov.au/default.htm

- CRC for Sensor Signal and Information Processing
- CRC for Smart Internet Technology
- CRC for Technology Enabled Capital Markets

Some former CRCs in ICT:
- CRC for Advanced Computational Systems
- CRC for Intelligent Decision Systems
- CRC for Robust and Adaptive Systems
- Research Data Network CRC

5.6 Australian Research Council Competitive Grant Funding

The Australian Research Council (ARC) is responsible for distributing a majority of the Commonwealth Government's research funding. It does so principally through its National Competitive Grants Programme (NCGP). Tables 5.6 and 5.7 show the number of successful ICT-related projects in the latest 2003 round.

Table 5.6: Successful ARC Discovery Project Grants in ICT - 2003

RFCD Code	RFCD Name	Number of Successful Applications
Total number of grants (including non-ICT-related)		921
2801	Information Systems	15
2802	Artificial Intelligence and Signal and Image Processing	25
2803	Computer Software	6
2804	Computational Theory and Mathematics	8
2805	Data Format	8
2899	Other Information, Computing and Communication Sciences	2
2916	Computer Software	1
2917	Communications Technologies	16

Source: http://www.arc.gov.au/ncgp/outcomes/default.htm

Table 5.7: Successful ARC Linkage Projects and Linkage APAI only Grants in ICT - 2003

RFCD Code	RFCD Name	Number of Successful Applications
Total number of grants (including non-ICT-related)		325
2801	Information Systems	10
2802	Artificial Intelligence and Signal and Image Processing	11
2803	Computer Software	5
2805	Data Format	2
2917	Communications Technologies	3

Source: http://www.arc.gov.au/ncgp/outcomes/default.htm

In the category of *Linkage Infrastructure, Equipment and Facilities* funding, a significant amount of the successful projects are ICT-related, even those classified outside of the RFCD categories listed in section 5.2 above. The relation to ICT is

mainly through technology usage and applications. Details of the projects can be found at http://www.arc.gov.au/ncgp/outcomes/2003/lief/LIEF_by_RFCD_code.rtf.

The ARC gives priority to application within a set of priority areas, identified as *"fields of existing or emerging research strength in which Australia can achieve international leadership and which have the potential to deliver significant economic and social benefits to the community"* (see http://www.arc.gov.au/ncgp/priorityareas.htm). Two of the four priority areas for 2003 round have some relations to ICT:

- Complex/Intelligent Systems
- Photon Science and Technology

See Appendix H for outcomes of applications to these priority areas in the 2003 round.

5.7 Key Findings

1. The Business sector has been the largest contributor to ICT research up until now. The potential for collaboration between the Business sector and Higher Education is large. Programmes like CRCs and ARC Linkage Projects provide further incentives to form such collaborations. However, collaborations of this kind require considerable time and effort due to logistics and intellectual property issues. Institutions need to have sufficient support and initiatives to ensure researchers and research teams can overcome barriers in forming such collaborations.

2. The ICT initiatives in the Commonwealth Government's *Backing Australia's Ability* policy statement can be linked directly to recommendations from Prime Minister's Science, Engineering and Innovation Council (PMSEIC 2000), and the Australian Chief Scientist (Batterham 2000). These recommendations are directly focussed on addressing Australia's fragmented research policy approach, and the country's growing ICT trade imbalance. Following this direction, funding in the future will likely be more focussed in the future to areas targeted for this purpose.

3. NICTA is likely to be a focus for the Commonwealth government in the ICT area, with access to major funding. This will likely have major implications on existing ICT research establishments around the country. However, it is unclear what those implications are.

4. Data and performance analysis of developments in research for ARC competitive grants are now more readily available through the ARC. Such data and information will be very useful for institutions to compare their performances and improve on success rates in grant applications as well as research outcomes.

6. ICT Education in Secondary Schools

6.1 Australian School System

Under the Australian Constitution, responsibility for school education is held by State and Territory governments. Within each State and Territory, Ministers, education departments, statutory authorities and individual schools determine their own policies and procedures for curriculum, course outcomes, accreditation, resource allocation, and teacher development.

In general, the levels within Australian schooling (called the Kindergarten to Year 12, or K-12, system) is split into the following:

- Pre-year 1.
- Primary – year 1 to 6, or year 1 to 7.
- Secondary – year 7 to 12, or year 8 to 12.
- Senior Secondary - year 11 and 12).

Different states use different ways of implementing pre-year 1 education, and determining the split between primary and secondary schooling. Schooling is compulsory until the end of the year they turn 15. This generally is when the students finish year 10. Therefore, *post-compulsory schooling* generally refers to year 11 and year 12, or senior secondary schooling.

Students finishing year 12 are qualified to enter higher education. According to ABS statistics[51], 29% of the 297,150 Australian students aged 15-19 who completed school in 1999 were enrolled in higher education in 2000. In Western Australia, the rate is lower at 25% of 31,596 students. Considering only those completing year 12, the rates are higher at 43% nationally (no numbers published for WA).

6.2 ICT in the National Goals for Schooling

In 1997, education ministers from the various states, meeting under Ministerial Council on Education, Employment Training and Youth Affairs (MCEETYA) agreed to a review of the national goals for Schooling. The result of the review was a report *National Report on Schooling in Australia* (MCEETYA 2000), and a declaration in 1999 of a new set of goals, *the Adelaide Declaration on National Goals for Schooling in the Twenty-first Century*.

Considerable attention is paid to ICT in the national report (chapter 10 in MEETYA 2000). The Adelaide Declaration makes a firm commitment to the development of ICT education. In particular, it states (in Goal 1.6) that,

> "*Schooling should develop fully the talents and capacities of all students. In particular, when students leave schools they should… be confident, creative and productive users of new technologies, particularly information and communication technologies, and understand the impact of those technologies on society*"

Through the Education Network Australia (EdNA) Reference Committee (ERC), an advisory committee to MCEETYA, an action plan *Learning for the Knowledge Society* (DETYA 2000) was also developed to provide a national agenda on ICT education and training.

[51] see http://online.curriculum.edu.au/anr2000/template/html/downloads/anr2000_Appendix_stat.pdf

6.3 WA School System

The Western Australian Department of Education currently operates under the *Schools Education Act 1999* and the *Schools Education Regulations 2000* to oversee and regulate the K-12 school education system in Western Australia. In 2001, there were a total of 258, 170 students in the system, 70.1% of which are in government schools (DE 2001).

The state's school curriculum development is handled by the Curriculum Council, operating under the *Curriculum Act 1997*. The Council is also responsible for course accreditation, and student assessment and certification. The curriculum is defined within a Curriculum Framework that encompasses all K-12 education.

Within the Framework, there are currently 33 Tertiary Entrance Exam (TEE) subjects, where the score from the exam can be used in the Tertiary Entrance Score (TES) to derive the Tertiary Entrance Rank (TER) for entry into higher education.

These 33 subjects are also part of a larger set of 415 subjects in year 11 and 12. They are commonly called Common Assessment Framework (CAF) subjects. The CAF subjects available in any school are up to the discretion and resources of the particular school.

6.4 ICT Curriculum in the WA School System

The current state curriculum as defined under the Curriculum Framework has an extensive number of ICT-related subjects. For the 2002/2003 round, all ICT-related subjects are under the learning area *Technology and Enterprise: Business and Computing*. The list consists of:

Year 11:

Technology and Enterprise: Business and Computing:

- Business Information Technology
- Digital Media
- Information Systems
- Personal Information Technology

Vocational Units:

- Computer Fundamentals
- Computerised Accounting
- Keyboard Operations - Application
- Keyboard Operations - Technique
- Computer Fundamentals for Hospitality and Tourism
- Computer Assisted Drawing and Design

Year 12:

Technology and Enterprise: Business and Computing:

- Business Information Technology
- Industry Information Technology
- Interactive Media
- Information Systems (TEE subject)

Vocational Units:

- Audio and Word Processing Skills

- Computer Fundamentals

The subject *Information Systems* in year 12 is a TEE subject, and the score from this subject can be used for tertiary entrance.

The description of each of the above subjects, and details of the year 12 *Information Systems* subject, can be found in Appendix E.

6.5 ICT in the Post-Compulsory Education Review

In 1998, the Council began a *Post Compulsory Education Review*. The review was prompted by the concern over low participation rate of post-compulsory schooling (over one-third of compulsory school students stay until year 12). Evidence seems to indicate that students without post-compulsory education are not equipped for the workforce and the progressively complex global community. One of the key challenges was how to convert a system designed for entrance into University, into a system that is more inclusive of different needs from the cross-section of students. Integrating with vocational education and training became an important part of secondary education.

The review culminated in a final report in November 2001 (CC 2001). The report identified some "*fundamental underpinning skills for the global environment*" (page 22). Highlighting the importance of ICT, it was named as one of three areas where competency is required, along with literacy and numeracy.

In the proposed new structure to a curriculum, ICT belongs in a course of study titled Applied Information, with Information Technology as a suggested subject. A preliminary overview of the course is given as:

> *"Students acquire and develop knowledge and skills related to the creation, manipulation, storage, retrieval and communication of information using a range of industry-level software and hardware. They learn to work in the climate of rapid change associated with information technology and appreciate its impact on individuals and social systems."* (page 15, CC 2002)

The exact structure for the new curriculum is still under review and trials. The time-line for gradually introducing this new curriculum is 2002-2007. We expect ICT to feature more prominently in secondary schooling in the coming years, especially as vocational training subjects.

6.6 Key Findings

1. School leavers coming into ICT degrees in higher education will likely have more and more background in formal education in ICT subjects. With current developments in secondary education, it may be that some school leavers will enter University having formally achieved the outcomes of some of our first year undergraduate units. Universities will have to consider how to effectively deal with this situation, while tackling the parallel problem of mature age entrants who may not have any exposure to the material at all.

2. With the diversification of options available within the secondary school system, and the introduction of VET subjects, school leavers will cover a much larger spectrum of backgrounds, interests and learning styles than before. Universities will have to advance flexible teaching delivery approaches to keep up with the diversity in this student population.

3. The W.A. Post-Compulsory Education Review and policy responses were prompted by pressures similar to those faced by higher education (eg. attracting students who are more focussed on job training and employment, rather than pure academic pursuit). Universities can gain valuable information by following the trials and errors of the current efforts to implement a new framework with the post-compulsory education system.

4. Secondary schooling considers ICT skills as a basic life-skill. Universities should do the same, and have a whole-of-University approach to ensuring all graduates have basic applied ICT skills.

7. ICT in Vocational Education and Training (VET)

7.1 VET in Australia

Vocational education and training in Australia is currently overseen by the Australian National Training Authority (ANTA). The system is run under the National Training Framework (NTF), made up of the Australian Quality Training Framework (AQTF) arrangements together with Training Packages. AQTF is part of the Australian Qualifications Framework as diagrammed in Figure 4.2.

VET has traditionally been post-secondary, non-university education and training directed towards specific skills at the workplace, and focusing on apprenticeships. But current demands on skills have seen VET being offered in secondary schools, and have stronger ties with university study-options.

VET training packages are offered through registered training organisations (RTOs). A major set of RTOs is within the Australian Technical and Further Education (TAFE) system. TAFE institutions are publicly funded to provide VET courses.

7.2 Training Packages in the NTF

A Training Package defines a set of workplace skills and knowledge. How the training is to be conducted, however, is left to the RTOs. Developing training packages are industry-led through national Industry Training Advisory Bodies (ITABs), recognised bodies responsible for identifying training needs of specific industries or industry sectors. Training packages must be endorsed by the National Training Quality Council (NTQC), and has a set review date to ensure relevancy and currency. An endorsed package must be placed on the National Training Information Service (NTIS).

In October 2002, there were 75 endorsed Training Packages.

7.3 IT&Titab

ICT packages on the NTIS are principally developed by the Information Technology and Telecommunications ITAB (IT&Titab)[52]. Figure 7.1 shows the relationship between the IT&Titab within the VET framework.

[52] http://www.ittitab.com.au/home.htm

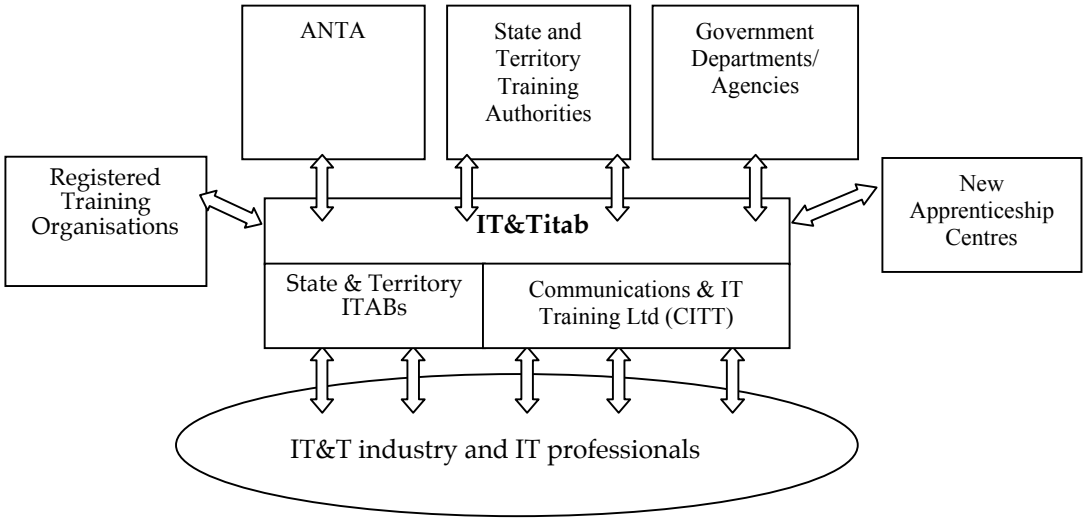

Figure 7.1: National IT&Titab and Structural Position. *Source: Reproduced from page 4, IT&Titab (2002).*

7.4 ICT Packages

There are currently two endorsed packages for ICT developed by the IT&Titab: *ICA99 Information Technology* and *ICT97 Telecommunications*. Qualifications offered in various streams under the two packages are:

ICA99 -- Information Technology
ICA10101 Certificate I in Information Technology
ICA20199 Certificate II in Information Technology
ICA20201 Certificate II in Information Technology (Applications)
ICA30199 Certificate III in Information Technology (Software Applications)
ICA30299 Certificate III in Information Technology (General)
ICA30399 Certificate III in Information Technology (Network Administration)
ICA40199 Certificate IV in Information Technology (Client Support)
ICA40299 Certificate IV in Information Technology (Database Administration)
ICA40399 Certificate IV in Information Technology (Network Management)
ICA40499 Certificate IV in Information Technology (Multimedia)
ICA40599 Certificate IV in Information Technology (Technical Support)
ICA40699 Certificate IV in Information Technology (Programming)
ICA40799 Certificate IV in Information Technology (Systems Analysis and Design)
ICA40801 Certificate IV in Information Technology (Helpdesk)
ICA40901 Certificate IV in Information Technology (Telesales)
ICA50199 Diploma of Information Technology (Systems Administration)
ICA50299 Diploma of Information Technology (Software Development)
ICA50399 Diploma of Information Technology (Business Analysis)
ICA50499 Diploma of Information Technology (Network Engineering)
ICA50599 Diploma of Information Technology (Multimedia Integration)

ICA99 -- Information Technology (E-Business)
ICA10201 Certificate I in Information Technology (E-Consumer)
ICA41001 Certificate IV in IT (Website Administration)

ICA41101 Certificate IV in IT (Website Design)
ICA50601 Diploma of IT (Website Development)
ICA50701 Diploma of IT (Internetworking)
ICA50801 Diploma of IT (E-Business Development)
ICA50901 Diploma of IT (Knowledge Management)
ICA51001 Diploma of IT (Database Design and Development)
ICA51101 Diploma of IT (Project Management)
ICA60101 Advanced Diploma of IT (E-Business Development)
ICA60201 Advanced Diploma of IT (E-Business Analysis)
ICA60301 Advanced Diploma of IT (E-Learning Development)
ICA60401 Advanced Diploma of IT (E-Security)
ICA60501 Advanced Diploma of IT (Project Management)

ICT97 -- Telecommunications (Cabling)
ICT20297 Certificate II in Telecommunications (Cabling)
ICT30497 Certificate III in Telecommunications (Cabling)
ICT40499 Certificate IV in Telecommunications (Cabling)

ICT97 -- Telecommunications (Call Centres)
ICT20499 Certificate II in Telecommunications (Call Centres)
ICT30599 Certificate III in Telecommunications (Call Centres)
ICT40599 Certificate IV in Telecommunications (Call Centres)

ICT97 -- Telecommunications (Customer Access Network)
ICT20399 Certificate II in Telecommunications (CAN)
ICT30397 Certificate III in Telecommunications (CAN)
ICT40397 Certificate IV in Telecommunications (CAN)
ICT50399 Diploma of Telecommunications (CAN)

ICT97 – Telecommunications (Customer Premises and Equipment)
ICT30297 Certificate III in Telecommunications (CPE)
ICT40297 Certificate IV in Telecommunications (CPE)
ICT50299 Diploma of Telecommunications (CPE)

ICT97 – Telecommunications (Customer Premises, Cabling and Equipment)
ICT30699 Certificate III in Telecommunications (Customer Premises, Cabling and Equipment)

ICT97 – Telecommunications (Engineering)
ICT50197 Diploma of Telecommunications Engineering
ICT60197 Advanced Diploma of Telecommunications Engineering

ICT97 – Telecommunications
ICT20197 Certificate II in Telecommunications
ICT30197 Certificate III in Telecommunications
ICT40197 Certificate IV in Telecommunications

The relationship between the various levels of certificates and diplomas in AQTF, and the qualifications in secondary and tertiary levels are illustrated in Figure 4.2.

Besides the qualifications available under a training package, there is also a range of ICT-related certificates and diplomas offered as individual qualifications. The

interested reader is referred to the NTIS web site http://www.ntis.gov.au for further details.

7.5 Review of ICA99 Training Package

The IT&Titab recently completed a substantial review of the ICA99 Training Package. Results of the review, as well as proposed changes, were published in a report (IT&Titab, 2002). Among the major review findings that may also be useful to higher education include:

- Over one third of potential ICA99 users fall outside the IT industry. Therefore the training packages need continual cross-industry cooperation and integration. (part of Finding 1, IT&Titab 2002)
- ICA99 must be able to support not just qualifications-based learning but a mix of competencies required to "up skill" those already in the labour market. (part of Finding 3)
- IT&T vendors, employers and recruiters consistently indicated that personnel not only need technical skills, but also have soft skills that contribute to the organisation's strategic success and growth. (part of Finding 5, IT&Titab 2002)
- Mobile applications, technologies and business solutions will require substantial vocational training support. (parts of Findings 7 and 8, IT&Titab 2002).
- There is no integrated national strategy on how the VET training packages is used in concert with other training and educational programmes to address the IT 'skills gaps'. (part of Finding 10, IT&Titab 2002)

7.6 Australian Flexible Learning (AFL) Framework[53]

The Australian Flexible Learning (AFL) Framework was developed by the Flexible Learning Advisory Group (FLAG), and endorsed by ANTA. It is a strategic response by the VET sector to the challenges created by this transition to the new economy. It is used to tackle key issues in the up-take of flexible learning, particularly online learning. It focuses on:

- enabling flexible delivery in VET, and
- promoting Australia as a global leader in the application of new technologies to VET products and services.

7.7 Key Findings

1. ICT training packages in the National Training Framework (NTF) have been developed with close attention to workplace skills, and close consultation with industry. Although the primary purpose of University curriculum development may not be exactly the same, we can still learn from developments of the vocational training packages. Demands from a changing student-body profile will apply pressure for this to happen.
2. Universities need to clarify their roles and relationships with the vocational training sector in providing education and training for graduates who will go into the ICT workforce. A clear vision of those roles and relationships will

[53] http://flexiblelearning.net.au/

allow Universities to develop articulations with vocational institutions to promote undergraduate courses among vocational students.

3. The IT&Titab review have indicated that training packages in ICT will need to undergo constant evolution due to rapid changes in this field. Universities need to have their own strategies for managing the same changes.

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Appendix A: Major Sources of Information

This Appendix lists all the information sources found during the current study that is likely to persist and be useful in future updates to the information in this report. We list them here to serve as the starting point for future follow-up studies.

Overall ICT Trends, Developments and Statistics in Australia

Australian Bureau of Statistics

- Information Technology Statistics Theme page <http://www.abs.gov.au> (select *Themes* then *Information Technology* from front page)
- Communications and Information Technology page <http://www.abs.gov.au> (select *Australia Now* then *Communications and Information Technology* from front page)

National Office for the Information Economy – Current State of Play reports <http://www.noie.gov.au/projects/framework/Progress/csop.htm>

Australian Information Industries Association - Market Intelligence publications <http://www.aiia.com.au>

Centre for Strategic Economic Studies, Victoria University - Information Industry and Technology Updates <http://www.cfses.com/infoind.htm>

IT Skills Hub <http://www.itskillshub.com.au/>

International ICT Trends, Developments and Statistics

OECD ICT page <http://www.oecd.org/> (select *Information and Communication Technologies* from front page)

United Nations Development Programme (UNDP) Networking and Information Technology Observatory <http://www.sdnp.undp.org/observatory/>

ICT Employment Statistics in Australia

Department of Employment and Workplace Relations' Vacancy Reports, http://www.workplace.gov.au (select *Publications* then *Employment*)

Developments in Education and Training in Australia

Department of Education, Science and Training, http://www.dest.gov.au/. Higher Education section at http://www.dest.gov.au/highered/.

Appendix B: ABS' Framework for Measuring the Knowledge-Based Economy

Below is the comprehensive set of knowledge-based economy dimensions, characteristics and indicators, as proposed by the Australian Bureau of Statistics in their current consultative discussion paper *Measuring a Knowledge-based Economy and Society - An Australian Framework* (ABS 2002b). The ICT dimension is listed in the 4th table.

1) THE CONTEXT DIMENSION:

Characteristic:	**Indicators:**
Macro-economic factors	• GDP • Exchange rates • Interest rates • Inflation
Social and cultural factors	• Age structure of the population • Income levels and distribution of the population • Participation in community activities
Product, financial and labour markets	• GDP Market Sector • Australian Stock Exchange(ASX) All ordinaries index • Labour market participation by age and sex • Industrial action, working days lost
Openness	• Foreign direct investment flows as a proportion of GDP • Trade openness: imports plus exports as a proportion of GDP
Legal and regulatory frameworks	*No indicators are proposed at this stage*
Political institutions and transparency	*No indicators are proposed at this stage*

2) INNOVATION AND ENTREPRENEURSHIP DIMENSION:

Characteristic:	**Indicators:**
Research base and potential for knowledge creation	• Total R&D expenditure by sector of performance (business, government, private non-profit, higher education), as a proportion of GDP • Total R&D expenditure by sector of performance. • Expenditure on basic research by sector of performance (business, government, private non-profit, higher education), as a proportion of GDP • Expenditure on basic research by broad discipline, as a proportion of GDP • Business R&D expenditure by business size • Number of scientific and technical publications, per capita

Knowledge creation with commercial potential	• Expenditure on applied research and experimental development by sector of performance, as a proportion of GDP • Business R&D expenditure by broad industry and by technology intensity of industry • Number of Australian resident patents in 'triadic' patent families (European Patent Office, US Patent and trademark Office and the Japanese Patent Office) per million population • Number of international patent applications filed with the World Intellectual Property Organisation (WIPO) by country of origin • Inventiveness co-efficient: number of resident patent applications per capita • Patent applications filed in Australia in particular fields
Other knowledge creation	• *No indicators proposed at this stage*
Knowledge networks and flows	• Business funding of R&D performed by other sectors as a proportion of total R&D expenditure • Proportion of Australian business R&D funded from overseas • Proportion of business R&D performed overseas but funded locally • Number of international strategic alliances between firms • Cross-border ownership of inventions, proportion of patent applications • Citation of scientific inventions in United States patents • International co-operation in science and technology: proportion of scientific publications with foreign co-authors • International co-operation in science and technology: proportion of patents with foreign co-inventors • International mobility of human capital: non national human resources in science and technology • International mobility of students: enrolled tertiary students who are not Australian citizens, proportion of total enrolment
Innovation	• Proportion of manufacturing businesses which are innovative by business size, industry and broad type of innovation (product, process or organisational) • Expenditure on technological innovation by manufacturing businesses by business size, industry and type of innovation (R&D, acquisition of technology etc)
Entrepreneurial activity	• Number of business startups (by Australian adults per capita) • Proportion of small and medium enterprises by industry (in growth industries defined in terms of both employment and output)
Support for innovation	• Government funded expenditure on R&D, as a proportion of GDP, by level of government • Government budget appropriations or outlays for R&D, as a proportion of GDP • Federal government financial support for science and innovation, by type of activity and theme • Value of venture capital provided as a proportion of GDP

3) HUMAN CAPITAL DIMENSION:

Characteristic:	**Indicators:**
Stock of skilled people	• Highest completed level of educational attainment of the population, by age and sex • Educational attainment of the labour force, by occupation and highest educational attainment • Knowledge workers as a proportion of the labour force • Researchers as a proportion of the labour force • Labour force status of those with science and technology qualifications • Stock of human resources in science and technology, proportion of population
Flow of skilled people	• Literacy and numeracy rates for children under 15 years • Participation in secondary and tertiary education, proportion of relevant age group • Graduates in science, IT and engineering as a proportion of total graduates • Graduate outcomes by qualification, employment status, field of study and occupation • Proportion of labour force in vocational training and apprenticeships • Immigration and emigration of skilled adults • Net change in stock of skilled workers
Investment in human capital	• Total expenditure on education, as a proportion of GDP, by source of funding • Expenditure on education by government, as a proportion of GDP, by education sector • Government expenditure per capita on government schools, by level of education and government • Income and expenditure of non-government schools, by level of education • Business expenditure on training and vocational education • Private expenditure on education
Lifelong learning and access to education and training	• Adult literacy levels: proportion of the population at International Adult Literacy level 3 or above • Proportion of population aged 15–64 in formal education, by field of study and age • Proportion of population aged 15–64 undertaking work-related training • Expected number of years spent in education and training • Proportion of undergraduate university applicants not receiving an offer through state admission centres • Unmet demand for education, by labour force characteristics • Visits to public library facilities, per capita

4) INFORMATION AND COMMUNICATIONS TECHNOLOGY DIMENSION:

Characteristic:	Indicators:
ICT infrastructure and access	• Internet services: number of Internet Service Providers, POPs and access lines by broad region • Number of Internet hosts (computers connected to the Internet) per capita • Broadband penetration rates (number of DSL and cable modem lines) per capita • Proportion of subscribers with broadband access (DSL and cable modem) • The price of Internet access and use, compared to other countries • Proportion of households reporting particular barriers to access to computers and the Internet • Access to the Internet via public libraries, proportion of individuals accessing the Internet • Public libraries offering technology facilities • Number of telecommunication access paths (total fixed access lines and mobile subscribers) per capita • Household expenditure on ICT goods and services
Household and individual use of ICT	• Proportion of households with access to a computer by type of household, income, broad region (metropolitan/non-metropolitan) • Proportion of households with access to a mobile phone by type of household, income, broad region (metropolitan/non-metropolitan) • Proportion of households with access to the Internet by type of household, income, broad region (metropolitan/non-metropolitan) • Number of household ISP subscribers by broad region • Volume of data downloaded by household ISP subscribers • Proportion of individuals accessing a computer by age, sex, occupation, level of education and broad region • Proportion of individuals accessing the Internet by age, sex, occupation, level of education and broad region • Proportion of individuals using the Internet for particular activities and purposes, including accessing government services • Proportion of children using a computer or the Internet at school, by age, sex and broad region • Proportion of teachers using a computer or the Internet, by age, sex and broad region
Business and government use of ICT	• Proportion of businesses and farms with computers, web sites, Internet access, by business/farm size • Proportion of businesses with Internet access, by broad industry group • Barriers to Internet use by businesses • Number of non-household (includes business and government) ISP subscribers • Government expenditure on ICT, as a proportion of total expenditure, by government type • Business expenditure on ICT

Prevalence of electronic commerce	• Proportion of businesses purchasing or selling via the Internet, by broad industry group • Proportion of business income attributable to selling goods or services over the Internet, by business size • Business perceptions of the impact of Internet selling on the business • Business perceptions of the benefits of Internet purchasing to the business • Proportion of individuals using the Internet to purchase goods and services, by value of purchases • Barriers to Internet purchasing by individuals • Number of secure web servers (those encrypted for the security of on-line transactions) per capita
ICT skill base	• ICT workers as a changing proportion of the labour force • Lack of skills as a constraint to business and individual use of computers and the Internet
Strength of the ICT industry	• ICT sector revenue by broad industry group • ICT sector proportion of total business value added • ICT sector proportion of total business employment • R&D performed by the ICT sector as a proportion of total business R&D • R&D expenditure on ICT, by sector. • ICT patents, proportion of total resident patent applications • Capital expenditure by the ICT sector as a proportion of total business capital expenditure • Production of ICT goods and services by broad commodity group • Trade in ICT goods and services by broad commodity group

5) ECONOMIC AND SOCIAL IMPACTS DIMENSION:

Characteristic:	**Indicators:**
Economic and structural change:	• GDP per capita • Labour productivity • Multifactor productivity • Correlation between ICT use and financial performance at firm level • Contribution of technology- and knowledge-intensive industries to Gross Value added (GVA) • Contribution of high technology imports and exports to total trade • Contribution of trade in business services to total trade • Exports of education and training services
Social change	• Relative earnings of employees by level of educational attainment • Relative earnings of the self-employed by level of educational attainment • Unemployment rates and duration of unemployment by highest level of educational attainment • Changes in patterns of work: teleworking trends among Australian workers

Appendix C: ICT in International Industrial Classifications

Source: OECD (2002)

International Standard Industrial Classification of All Economic Activities (ISIC Rev.3)

Manufacturing
- 3000 Manufacture of office, accounting and computing machinery
- 3130 Manufacture of insulated wire and cable
- 3210 Manufacture of electronic valves and tubes and other electronic components
- 3220 Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
- 3230 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
- 3312 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
- 3313 Manufacture of industrial process control equipment
- 3694 Manufacture of games and toys

Services: goods-related
- 5150 Wholesale of machinery, equipment and supplies
- 7123 Renting of office machinery and equipment (including computers)

Services: intangible
- 6420 Telecommunications
- 7200 Computer and related activities

Reed Electronics Research, Yearbook of World Electronics Data 2001.

The six main groups that comprise ICT goods, and their corresponding Standard International Trade Classification (SITC) Revision 3 codes, are as follows:

- Electronic data processing (EDP) equipment: 752.1, 752.2, 752.3, 752.6, 752.7, 752.9, 759.9.
- Office equipment: 751.1, 751.2, 763.3, 763.8, 751.3, 759.1.
- Control and instrumentation: 778.7, 874.1, 874.2, 874.3, 874.4, 874.5, 874.6, 874.7
- Radiocommunications (including mobiles) and radar: 764.3, 764.8, 764.9, 874.1.
- Telecommunications: 764.1, 764.9, 763.8.
- Consumer equipment: 763.8, 764.8, 761.1, 761.2, 763.3, 763.8, 762.1, 762.2, 762.8, 881.1, 885.3, 885.4, 885.7, 898.2.
- Components: 776.2, 776.3, 776.4, 776.8, 771.1, 771.2, 778.6, 772.2, 772.3, 772.4, 772.5, 764.2, 764.9, 898.4, 761.1.

Standard International Trade Classification (SITC) Revision 3 codes

- Computer equipment: 752, 759.97.

- Communication equipment: 764.1, 764.3, 764.81, 764.91.
- Electronic components: 772.2, 772.3, 776.1+776.27, 776.3, 776.4, 776.8, 778.6, 776.29.

Harmonised Commodity Description and Coding System (HS) Rev.2

- 852431: discs, recorded, for laser reading systems, for reproducing phenomena other than sound or image.
- 852439: discs, recorded, for laser reading systems, for reproducing sound and image or image only.
- 852440: magnetic tapes, recorded, for reproducing phenomena other than sound or image.
- 852491: recording media
- 852499: recorded media for sound or image reproducing phenomena, including matrices and masters for the production of records

Balance of Payments Coding System (BPM5)

For ICT services:

- 262: computer and information services.
- 245: communications services.

International Patent Classification (IPC) classes

- G06: computing, calculating, counting devices.
- G11: information storage equipment.
- H04: electrical communication systems.

Appendix D: Standard ICT Academic Classifications

Department of Education, Science and Training's Fields of Education, based on Australian Standard Classification of Education (ASCED)

DEST's *Field of Education* was introduced in 2001 and "used to describe higher education courses, specialisations and units of study. The main purpose of the classification is to ensure courses, specialisations and units of study with the same or similar vocational emphasis are reliably classified to the same field of education" (DEST, 2002b). It replaces the *Field of Study* and *Academic Organisational Unit Groups codes based on Discipline Groups* categorisations used in the past.

In the post-2001 Fields of Education, ICT areas are mostly grouped under *Information Technology*. Some areas also appear under *Engineering* and *Management and Commerce*.

Source: 1272.0 Australian Standard Classification of Education (ASCED), available http://www.abs.gov.au/AUSSTATS/abs%40.nsf/66f306f503e529a5ca25697e0017661f/f501c031bd9ac9c5ca256aaf001fca33!OpenDocument

02.00.00 INFORMATION TECHNOLOGY

- 02.01.00 Computer Science
  - 02.01.01 Formal Language Theory
  - 02.01.03 Programming
  - 02.01.05 Computational Theory
  - 02.01.07 Compiler Construction
  - 02.01.09 Algorithms
  - 02.01.11 Data Structures
  - 02.01.13 Networks and Communications
  - 02.01.15 Computer Graphics
  - 02.01.17 Operating Systems
  - 02.01.19 Artificial Intelligence
  - 02.01.99 Computer Science not elsewhere classified
- 02.03.00 Information Systems
  - 02.03.01 Conceptual Modelling
  - 02.03.03 Database Management
  - 02.03.05 Systems Analysis and Design
  - 02.03.07 Decision Support Systems
  - 02.03.99 Information Systems not elsewhere classified
- 02.99.00 Other Information Technology
  - 02.99.01 Security Science
  - 02.99.99 Information Technology not elsewhere classified

03.00.00 ENGINEERING AND RELATED TECHNOLOGIES

- 03.13.00 Electrical and Electronic Engineering and Technology
  - 03.13.05 Computer Engineering
  - 03.13.07 Communications Technologies

08.00.00 MANAGEMENT AND COMMERCE

- 08.09.00 Office Studies
  - 08.09.03 Keyboard Skills
  - 08.09.05 Practical Computing Skills

Australian Standard Research Classification (ASRC) 1998: Chapter 3 - Research Fields, Courses and Disciplines (RFCD) classification

The RFCD classification has been designed primarily to meet the needs of the Australian Bureau of Statistics and the Department of Education, Science and Training. It classifies courses and research projects to field of study/research and classifying units of study to discipline. Areas in ICT is grouped under *280000 Information, Computing and Communication Sciences*, *291600 Computer Hardware* and *291700 Communications Technologies*. The lists is available from http://www.abs.gov.au/ausstats/abs%40.nsf/66f306f503e529a5ca25697e0017661f/955ffa4eb1b23847ca25697e0018fb14!OpenDocument. The following is the structure:

Division 280000 Information, Computing and Communication Sciences

280100 Information Systems
- 280101 Information Systems Organisation
- 280102 Information Systems Management
- 280103 Information Storage, Retrieval and Management
- 280104 Computer-Human Interaction
- 280105 Interfaces and Presentation (excl. Computer-Human Interaction)
- 280106 Interorganisational Information Systems
- 280107 Global Information Systems
- 280108 Database Management
- 280109 Decision Support and Group Support Systems
- 280110 Systems Theory
- 280111 Conceptual Modelling
- 280112 Information Systems Development Methodologies
- 280199 Information Systems not elsewhere classified

280200 Artificial Intelligence and Signal and Image Processing
- 280201 Expert Systems
- 280202 Computer Graphics
- 280203 Image Processing
- 280204 Signal Processing
- 280205 Text Processing
- 280206 Speech Recognition
- 280207 Pattern Recognition
- 280208 Computer Vision
- 280209 Intelligent Robotics
- 280210 Simulation and Modelling
- 280211 Virtual Reality and Related Simulation
- 280212 Neural Networks, Genetic Alogrithms and Fuzzy Logic
- 280213 Other Artificial Intelligence

280300 Computer Software
- 280301 Programming Techniques
- 280302 Software Engineering
- 280303 Programming Languages
- 280304 Operating Systems
- 280305 Multimedia Programming
- 280399 Computer Software not elsewhere classified

280400 Computation Theory and Mathematics
280401 Analysis of Algorithms and Complexity
280402 Mathematical Logic and Formal Languages
280403 Logics and Meanings of Programs
280404 Numerical Analysis
280405 Discrete Mathematics
280406 Mathematical Software
280499 Computation Theory and Mathematics not elsewhere classified

280500 Data Format
280501 Data Structures
280502 Data Storage Representations
280503 Files
280504 Data Encryption
280505 Data Security
280506 Coding and Information Theory
280599 Data Format not elsewhere classified

289900 Other Information, Computing and Communication Sciences
289999 Other Information, Computing and Communication Sciences

Division 290000 Engineering and Technology

291600 Computer Hardware
291601 Arithmetic and Logic Structures
291602 Memory Structures
291603 Input, Output and Data Devices
291604 Logic Design
291605 Processor Architectures
291699 Computer Hardware not elsewhere classified

291700 Communications Technologies
291701 Antenna Technology
291702 Optical and Photonic Systems
291703 Digital Systems
291704 Computer Communications Networks
291705 Microwave and Millimetrewave Technology
291706 Broadband Network Technology
291707 Modem Technology
291708 Baseband Technology
291709 Satellite Communications
291710 Radio Communications and Broadcasting not elsewhere classified
291799 Communications Technologies not elsewhere classified

ISCED 1997 Broad Groups and Fields of Education

The International Standard Classification of Education (ISCED) was designed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) to serve as an instrument suitable for assembling, compiling and presenting statistics of education both within individual countries and internationally. The present classification, known as ISCED 1997, was approved by the UNESCO General

Conference at its 29th session in November 1997. The classification details are available from http://www.uis.unesco.org/en/act/act_p/isced.html.

In ISCED 1997, ICT is classified in two groups, emphasising the software versus hardware difference:

48 Computing

Computer sciences: system design, computer programming, data processing, networks, operating systems - software development only (hardware development should be classified with the engineering fields).

52 Engineering and engineering trades

Engineering drawing, mechanics, metal work, electricity, electronics, telecommunications, energy and chemical engineering, vehicle maintenance, surveying.

ACS Areas of Knowledge

From Australian Computer Society (ACS) Areas of Knowledge 5.1 - 5.14:
http://www.acs.org.au/static/national/pospaper/bokpt1.htm

5.1 Computer Organisation and Architecture

- Computer Architecture and Instruction Set Design
- Review of Assembly Language Instructions with particular emphasis on instructions used in I/O programming
- Interfacing assembly language routines with a high level language (e.g. C)
- The Operation of Basic System Utilities - Assembler, Linker & Loader
- An Introduction to I/O Programming
    - Accessing I/O devices and polled I/O
    - Interrupt driven I/O
    - Interrupt Controllers and the Interrupt Mechanism
    - DMA and IO Channels
- Memory
    - An overview of Memory Module Design
    - The principles of operation of Cache Memory
    - The principles of operation of Virtual Memory Systems
- The Operation of the CPU
    - Overview of Control Unit Design - Hardwired vs Microprogrammed
    - Arithmetic Logic Unit - Carry Prediction (at gate level)
    - Pipelining - issues involved in Arithmetic and Instruction pipeline design
    - CISC vs RISC
- Review of the Implementation of DOS and UNIX File Systems

5.2 Conceptual Modelling

- Abstraction and Modelling
    - Abstraction and modelling - classification, classes, types and instances, generalisation, inheritance, association and aggregation. Models as partial views providing particular perspectives - data, processes, objects, events and time, locations, user and organisational structures and roles, motivations and business purposes.
- Semantic data modelling

    - Entity relationship modelling - entity types, relationship types and attribute types
- The Relational Data Model
    - Transforming entity relationship models into relational models
    - Set theory
    - Relational structures - domains, base relations, virtual relations, tuples, attributes, candidate, primary and foreign keys
    - Relational integrity constraints - entity, referential and domain integrity
    - Relational manipulation operations - relational algebra and calculus
- Normalisation
    - Anomalies caused by redundant data in relations
    - Functional dependency, normalisation and normal forms
- The Structured Query Language
    - Data definition statements - create, drop, alter
    - Data manipulation statements - select, update, delete and insert
    - Access control statements - grant, revoke

5.3 Database Management

- File Processing
    - I/O operations
    - physical and logical files
    - buffer management
- File Structure Concepts
    - file access
    - performance issues
    - indexed files
    - B-trees
    - indexed sequential access
    - B+trees
    - VSAM files
    - hashing
- Schema Architecture
    - fact based
    - relational
    - hierarchical
    - network
- Query Languages
    - foundations
    - query processing and optimisation
- Concurrency Control
- Crash Recovery and Transaction Management

5.4 Data Communications and Networks

- Signals, Impairments and Media
- Communications Techniques
- Link Control and Efficiency
- Networking
- Local Area Networks
- Wide Area Networks
- Network Management
- Network Security
- Network Applications

5.5 Data Structures and Algorithms

- Data Types
- Simple data types
    - numeric, text
- Structured data types
    - arrays, records
- Abstract data types
    - stacks, queues, linked lists, trees
- File Organisation and Processing
    - serial/sequential files, indexed files, hash- addressed files
    - sequential and direct access methods
- Typical Operations on Data Structures
    - construction
    - sorting, searching, indexing
    - updating - additions/deletions/amendments
- Implementation/Representation
    - internal representation of data types
    - file index structures
    - treatment of collisions and overflow

5.6 Discrete Mathematics

- Computer Arithmetic
    - Numbering systems e.g., decimal, binary, octal and hexadecimal
- Set Theory
    - Definitions and notation
    - Venn diagrams
    - Set operations
    - The algebra of sets
    - Enumeration techniques
        - permutations and combinations
    - Inclusion/exclusion principle
    - Multinomial coefficients
- Logic
    - Simple and compound propositions
    - Propositional calculus
    - Truth tables
    - Properties of logic
- Boolean Algebra
    - Axioms
    - Functions and their determination
    - Switching circuits and properties
    - Normal forms
    - Simplification of Boolean functions and networks
- Graph Theory
    - Graphs
    - Euler and Hamiltonian graphs
    - Isomorphisms and isomorphic graphs
    - Planar graphs
    - Applications
- Matrix Theory
    - Definition of a matrix
    - Basic operations and the algebra of matrices
    - Applications

5.7 Ethics/Social Implications/Professional Practice
- Introduction
  - What's Ethics got to do with me?
- Social Issues
  - Culture and heritage
  - Culture and technology
- Global issues
- Organisational issues
  - Application of technology in Australian business
  - Ethical issues in private and public sectors
- Technology
- Belief Systems
  - The law and computer crime
  - Reliability, safety in software systems
- Individual
  - Responsibility - personal and community
- IT Professional Codes
  - ACS Code of Ethics
  - ACS Code of Conduct

5.8 Interpersonal Communications
- Written communication
  - effective expression
  - logical ordering of ideas
  - format and content of reports and formal documents
  - technical writing and documentation proposals and procedures
- Verbal communication
  - structuring material for oral presentation
  - visual presentation of information
  - the use of appropriate supporting technology
  - effective speaking and audience management
- Interpersonal skills
  - interview techniques
  - managing group dynamics
    - technical reviews
    - formal and informal meetings
  - negotiation skills
  - team management and conflict resolution

5.9 Program Design and Implementation
- Program specification
  - design of documentation to specify the requirements of a program
- Program design
  - algorithm design and associated documentation
  - program structure and logic
  - data design
- Programming languages
  - levels of languages in terms of machine vs user orientation
  - suitability of languages for problem domains
  - an appreciation of the operation of programs at machine level
- Program implementation
  - structure and syntax of a programming language
  - the procedures of editing, compiling, linking, etc, needed to produce an executable program

- internal documentation issues
- Program testing
  - formal proof of correctness vs testing procedures
  - design of test data
  - program testing methods
- Program documentation
  - internal and external program documentation
  - differing documentation requirements for technical staff and users
- Programming paradigms
  - an appreciation of the existence of and fundamental differences between procedural, functional, logic and object-oriented paradigms

5.10 Project Management and Quality Assurance

- Concepts and Models
  - project definition
  - project success
  - measuring success
  - post-implementation reviews
  - project size
    - lines of code
    - effort/duration
    - function points
  - project life cycle
- Project Management Techniques
  - steering committees
  - project justification
  - project planning
  - project development strategies
  - methodologies
  - risk assessment
  - estimation
  - quality assurance
  - scheduling
  - project tracking and reporting
- Introduction to Software quality
  - Understanding and Measuring Quality
  - The Costs and Benefits of Quality
  - Role of People in Producing Quality Software
  - Factors that Impact the Quality of Software
- Software Quality Planning
  - Role of Planning
  - Software Quality Requirements
  - Preparing a Software Quality Plan
  - Implementing a Software Quality Plan
  - Preparing a Quality Manual
- Processes for Assuring the Quality of Software
  - Risk Management
  - Conformance to Standards
  - Reviews, Audits, Walkthroughs and Inspections
  - Verification, Validation and Testing
  - Configuration Management
- Product Quality
  - Software Product Standards

- Quality Attributes of Software
- Product Characteristics of Quality Software
- Measuring and Evaluating Product Quality and Associated Metrics

- Process Quality
  - Software Process Standards
  - Process Definition
  - Process Measurement
- Process Assessment
  - Process Improvement
  - Capability Evaluation
  - Procurement of Software
- Post Development Software Quality Assurance
  - Maintenance and Evolution of Software
  - Re-engineering of Software
  - Software Product Quality Improvement

5.11 Information Security

- Historical Background
  - role of information technology professionals
- Societal, Governmental and Legal Imperatives for Information Systems
  - Security and Privacy
  - International guidelines (OECD Privacy and Information Systems Security Guidelines)
  - Regional security requirements (European Community)
  - Legal requirements - Australia's Privacy Act, State privacy and computer security / crime related Acts and Regulations
  - Australian standards for information security
- Professional Responsibility and Information Systems Security
  - Relationships between concepts of Quality, Safety, Reliability, and Security / Software Engineering
- Computer Security
  - Hardware requirements and features
  - Operating systems security
    - Access control, Authentication, Integrity, Confidentiality e.g. RACF, ACF-2, etc.
  - UNIX security (an example of techniques)
  - Database security
  - Personal computer/Small systems security
- Security Technologies
  - Access control mechanisms
  - Algorithms - Hash, One-way and Related Functions / SHA, ISO
  - Cryptography
    - Symmetric and Asymmetric techniques
    - commonly-used ciphers: DES, RSA, RC2-4, IDEA, SAFER, etc.
    - Key Management
    - Modes of usage
  - Authentication architectures
    - third party schemes/certificates

- Network Security
  - early proprietary and mainframe technologies - IBM, DEC

- Open Systems Interconnection security architecture (ISO 7498-2)
  - security services and mechanisms
- MIT "Kerberos"
- ECMA model - "SESAME"
- security and telecommunications services
  - computer-telephone integration

- Trusted Systems and Networks
  - "Rainbow" series (USA) / National Criteria, e.g. Canada, Australia, and others
  - ITSEC / ITSEM (Europe)
    - concepts of security functionality and enforcement/verification
  - Common criteria
  - Significance of trusted systems technologies
    - verification techniques and software engineering
- Security in the Distributed Systems (Client/Server) and Object Oriented Environments
- Security and Specific Industry Requirements
  - Health care industry
  - Banking and finance industry
  - Commercial and military government systems
- Security Management
  - Responsibilities
  - Organisation
  - Management requirements

5.12 Software Engineering and Methodologies

- Fundamentals of Software Engineering
  - requirements analysis
  - functional and technical specifications
  - process, data and object orientation models
  - documentation standards
  - software testing
  - software maintenance
  - software quality assurance
  - formal specification methods
  - software configuration management
- Project Management
  - project planning, estimation and control
  - project evaluation and control techniques
  - team construction and management
  - principles of software project management
  - prototyping

5.13 Systems Analysis and Design

- Role of Information Systems in an Organisation
- System Development Methodologies
  - Different systems development life cycle models such as waterfall, spiral, evolutionary, prototyping
  - Phases, stages, activities and stakeholders, deliverables, models and modelling techniques.
  - Common system development methodologies - structured analysis and design, information engineering and object oriented approaches

- Fact Finding Techniques
    - scussions, forms and documents, observation.
- The role of Models and Modelling Techniques
    - A framework for relating and understanding models - planning, analysis, design and implementation stages versus data, process, behaviour, location, organisation and motivation perspectives.
- Business Area Analysis
    - Problems, participants, physical versus essential models,
    - Typical modelling techniques based on any one development methodology or paradigm which may include data flow diagrams, functional decomposition diagrams, functional dependency diagrams, decision tables / trees, state transition diagrams, process descriptions, entity relationship diagrams, class diagrams, object diagrams, interaction diagrams, module diagrams, etc.
- Business Systems Design
    - Constraints, problems and participants. Deciding on the automation boundary. Design options. Typical modelling techniques based on any one development methodology or paradigm which may include structure charts, dialog flow diagrams, module diagrams, call graphs,etc. User interface design - ergonomics, data entry and validation, input forms, windows, window objects, screens and reports. Transforming analysis models into design models.
- Supporting Analysis and Design
    - The use of proformas and standards, system dictionaries and CASE tools.
- Project Management
    - Team structures, project scenarios, risk assessment, monitoring and measurement, tools PERT/ CPM
- Quality Assurance
    - Walkthroughs, inspects, reviews, consistency checks

5.14 Systems Software

- An operating system at the user level
    - command processing and scripts
    - security and administration in a modern operating system
- An operating system at the systems programming level
    - an operating system kernel
    - low-level facilities;
    - processes and state vectors;
    - hardware interface via interrupt handling
- Process management, including:
    - process synchronisation
    - process scheduling
    - models for interprocess communication (ipc)
    - threads and thread management
    - specification of concurrent systems
- Resource management, including:
    - file system and device (i/o) management
    - deadlock preconditions and process graphs
    - memory management issues and algorithms

CC2001 Computer Science Body of Knowledge

From Computing Curricula 2001 project (CC2001), a joint undertaking of the Computer Society of the Institute for Electrical and Electronic Engineers (IEEE-CS) and the Association for Computing Machinery (ACM). Further detailed breakdown is available from http://www.acm.org/sigcse/cc2001/.

Discrete Structures (DS)

DS1. Functions, relations, and sets [core]
DS2. Basic logic [core]
DS3. Proof techniques [core]
DS4. Basics of counting [core]
DS5. Graphs and trees [core]
DS6. Discrete probability [core]

Programming Fundamentals (PF)

PF1. Fundamental programming constructs [core]
PF2. Algorithms and problem-solving [core]
PF3. Fundamental data structures [core]
PF4. Recursion [core]
PF5. Event-driven programming [core]

Algorithms and Complexity (AL)

AL1. Basic algorithmic analysis [core]
AL2. Algorithmic strategies [core]
AL3. Fundamental computing algorithms [core]
AL4. Distributed algorithms [core]
AL5. Basic computability [core]
AL6. The complexity classes P and NP [elective]
AL7. Automata theory [elective]
AL8. Advanced algorithmic analysis [elective]
AL9. Cryptographic algorithms [elective]
AL10. Geometric algorithms [elective]
AL11. Parallel algorithms [elective]

Architecture and Organization (AR)

AR1. Digital logic and digital systems [core]
AR2. Machine level representation of data [core]
AR3. Assembly level machine organization [core]
AR4. Memory system organization and architecture [core]
AR5. Interfacing and communication [core]
AR6. Functional organization [core]
AR7. Multiprocessing and alternative architectures [core]
AR8. Performance enhancements [elective]
AR9. Architecture for networks and distributed systems [elective]

Operating Systems (OS)

OS1. Overview of operating systems [core]
OS2. Operating system principles [core]
OS3. Concurrency [core]

OS4. Scheduling and dispatch [core]
OS5. Memory management [core]
OS6. Device management [elective]
OS7. Security and protection [elective]
OS8. File systems [elective]
OS9. Real-time and embedded systems [elective]
OS10. Fault tolerance [elective]
OS11. System performance evaluation [elective]
OS12. Scripting [elective]

Net-Centric Computing (NC)

NC1. Introduction to net-centric computing [core]
NC2. Communication and networking [core]
NC3. Network security [core]
NC4. The web as an example of client-server computing [core]
NC5. Building web applications [elective]
NC6. Network management [elective]
NC7. Compression and decompression [elective]
NC8. Multimedia data technologies [elective]
NC9. Wireless and mobile computing [elective]

Programming Languages (PL)

PL1. Overview of programming languages [core]
PL2. Virtual machines [core]
PL3. Introduction to language translation [core]
PL4. Declarations and types [core]
PL5. Abstraction mechanisms [core]
PL6. Object-oriented programming [core]
PL7. Functional programming [elective]
PL8. Language translation systems [elective]
PL9. Type systems [elective]
PL10. Programming language semantics [elective]
PL11. Programming language design [elective]

Human-Computer Interaction (HC)

HC1. Foundations of human-computer interaction [core]
HC2. Building a simple graphical user interface [core]
HC3. Human-centered software evaluation [elective]
HC4. Human-centered software development [elective]
HC5. Graphical user-interface design [elective]
HC6. Graphical user-interface programming [elective]
HC7. HCI aspects of multimedia systems [elective]
HC8. HCI aspects of collaboration and communication [elective]

Graphics and Visual Computing (GV)

GV1. Fundamental techniques in graphics [core]
GV2. Graphic systems [core]
GV3. Graphic communication [elective]
GV4. Geometric modeling [elective]
GV5. Basic rendering [elective]

GV6. Advanced rendering [elective]
GV7. Advanced techniques [elective]
GV8. Computer animation [elective]
GV9. Visualization [elective]
GV10. Virtual reality [elective]
GV11. Computer vision [elective]

Intelligent Systems (IS)

IS1. Fundamental issues in intelligent systems [core]
IS2. Search and constraint satisfaction [core]
IS3. Knowledge representation and reasoning [core]
IS4. Advanced search [elective]
IS5. Advanced knowledge representation and reasoning [elective]
IS6. Agents [elective]
IS7. Natural language processing [elective]
IS8. Machine learning and neural networks [elective]
IS9. AI planning systems [elective]
IS10. Robotics [elective]

Information Management (IM)

IM1. Information models and systems [core]
IM2. Database systems [core]
IM3. Data modeling [core]
IM4. Relational databases [elective]
IM5. Database query languages [elective]
IM6. Relational database design [elective]
IM7. Transaction processing [elective]
IM8. Distributed databases [elective]
IM9. Physical database design [elective]
IM10. Data mining [elective]
IM11. Information storage and retrieval [elective]
IM12. Hypertext and hypermedia [elective]
IM13. Multimedia information and systems [elective]
IM14. Digital libraries [elective]

Social and Professional Issues (SP)

SP1. History of computing [core]
SP2. Social context of computing [core]
SP3. Methods and tools of analysis [core]
SP4. Professional and ethical responsibilities [core]
SP5. Risks and liabilities of computer-based systems [core]
SP6. Intellectual property [core]
SP7. Privacy and civil liberties [core]
SP8. Computer crime [elective]
SP9. Economic issues in computing [elective]
SP10. Philosophical frameworks [elective]

Software Engineering (SE)

SE1. Software design [core]
SE2. Using APIs [core]

SE3. Software tools and environments [core]
SE4. Software processes [core]
SE5. Software requirements and specifications [core]
SE6. Software validation [core]
SE7. Software evolution [core]
SE8. Software project management [core]
SE9. Component-based computing [elective]
SE10. Formal methods [elective]
SE11. Software reliability [elective]
SE12. Specialized systems development [elective]

Computational Science and Numerical Methods (CN)

CN1. Numerical analysis [elective]
CN2. Operations research [elective]
CN3. Modeling and simulation [elective]
CN4. High-performance computing [elective]

IS'97 Body of Information Systems Knowledge

From Information Systems '97 (IS'97), formed by a collaborative joint task force of the Association for Computing Machinery (ACM), the Association for Information Systems (AIS), and the Association of Information Technology Professionals (AITP). Further details are available at http://www.is2000.org/is97/rev/review1.html.

1.0 Information technology

1.1 Computer architectures

1.1.1 Fundamental data representation: non-numeric, numeric (integers, reals, errors, precision)
1.1.2 Physical representation of digitized information: e.g., data, text, image, voice, video
1.1.3 CPU architectures: CPU, memory, registers, addressing modes, instruction sets
1.1.4 Computer system components: busses, controllers, storage systems, peripheral devices
1.1.5 Multiprocessor architectures
1.1.6 Digital logic and systems

1.2 Algorithms and data structures

1.2.1 Formal problems and problem solving
1.2.2 Basic data structures: lists, arrays, strings, records, sets, linked-lists, stacks, queues, trees, graphs
1.2.3 Complex data structures: e.g., of data, text, voice, image, video, hypermedia
1.2.4 Abstract data types
1.2.5 File structures: sequential, direct access, hashing, indexed
1.2.6 Sorting and searching data structures and algorithms
1.2.7 Algorithm efficiency, complexity and metrics
1.2.8 Recursive algorithms
1.2.9 Neural networks and genetic algorithms

1.2.10 Advanced considerations

1.3 Programming languages

1.3.1 Fundamental programming language structures; comparison of languages and applications
1.3.2 Machine and assembly level languages
1.3.3 Procedural languages
1.3.4 Non-procedural languages: logic, functional, event driven
1.3.5 Fourth-generation languages
1.3.6 Object oriented extensions to languages
1.3.7 Programming languages, design, implementation and comparison

1.4 Operating systems

1.4.1 Architecture, goals and structure of an operating system; structuring methods, layered models, object-server model
1.4.2 Interaction of operating system and hardware architecture
1.4.3 Process management: concurrent processes, synchronization
1.4.4 Memory management
1.4.5 Resource allocation and scheduling
1.4.6 Secondary storage management
1.4.7 File and directory systems
1.4.8 Protection and security
1.4.9 Distributed operating systems
1.4.10 OS support for human interaction: e.g., GUI, interactive video
1.4.11 OS interoperability and compatibility: e.g., open systems
1.4.12 Operating system utilities, tools, commands and shell programming
1.4.13 System administration and management

1.5 Telecommunications

1.5.1 International telecommunication standards, models, trends
1.5.2 Data transmission: media, signaling techniques, transmission impairments, encoding, error detection, compression
1.5.3 Line configuration: error control, flow control, multiplexing
1.5.4 Local area networks
1.5.5 Wide area networks: switching techniques, broadcast techniques, routing
1.5.6 Network architectures and protocols
1.5.7 Internetworking
1.5.8 Network configuration, performance analysis and monitoring
1.5.9 Network security: encryption, digital signatures, authentication
1.5.10 High-speed networks: e.g., broadband ISDN, SMDS, ATM, FDDI
1.5.11 Emerging networks: ATM, ISDN, satellite nets, optic nets, etc., integrated voice, data and video
1.5.12 Application: e.g., client server, EDI, EFT, phone network, e-mail, multimedia, video conferencing, value-added networks

1.6 Database

1.6.1 DBMS: features, functions, architecture
1.6.2 Data models: relational, hierarchical, network, object, semantic object
1.6.3 Normalization
1.6.4 Integrity (referential, data item, intra-relation): representing relationships; entity and referential integrity
1.6.5 Data definition languages (schema definition languages, graphical development tools, dictionaries, etc.)
1.6.6 Application interface
1.6.7 Intelligent query processors and query organization, OLAP tools
1.6.8 Distributed databases, repositories and warehouses
1.6.9 DBMS products: recent developments in database systems (e.g., hypertext, hypermedia, optical disks)
1.6.10 Database machines and servers
1.6.11 Data and database administration
1.6.12 Data dictionary, encyclopedia, repository
1.6.13. Information retrieval: e.g. internet tools, image processing, hypermedia

1.7 Artificial intelligence

1.7.1 Knowledge representation
1.7.2 Knowledge engineering
1.7.3 Inference processing
1.7.4 Other techniques: fuzzy logic, CASE-based reasoning, natural language and speech recognition
1.7.5 Knowledge-based systems

2.0 Organizational and management concepts

2.1 General organization theory

2.1.1 Hierarchical and flow models of organizations
2.1.2 Organizational work groups
2.1.3 Organizational span: single user, work group, team, enterprise, global
2.1.4 Role of IS within the enterprise: strategic, tactical and operations
2.1.5 Effect of IS on organizational structure; IS and continuous improvement
2.1.6 Organizational structure: centralized, decentralized, matrix
2.1.7 Organizational issues pertaining to use of software systems in organizations

2.2 Information systems management

2.2.1 IS planning
2.2.2 Control of the IS function: e.g., EDP auditing, outsourcing
2.2.3 Staffing and human resource management
2.2.4 IS functional structures -- internal vs outsourcing
2.2.5 Determining goals and objectives of the IS organization
2.2.6 Managing IS as a business: e.g., customer definition, defining IS mission, IS critical success factors
2.2.7 CIO and staff functions

2.2.8 IS as a service function: performance evaluation -- external/internal, marketing of services

3.0 Theory and Development of Systems

3.1 Systems and Information Concepts
3.2 Approaches to Systems Development
3.3 Systems Development Concepts and Methodologies
3.4 Systems Development Tools and Techniques
3.5 Application Planning
3.6 Risk Management
3.7 Project Management
3.8 Information and Business Analysis
3.9 Information Systems Design
3.10 Systems Implementation and Testing Strategies
3.11 Systems Operation and Maintenance
3.12 Systems Development for Specific Types of Information Systems

Career Space Consortium's Generic Skills Profiles

Career Space is a consortium of eleven major ICT companies and the European ICT Industry Association (EICTA), formed to promote ICT and to advise the European Commission on narrowing the ICT skill gaps. The ICT companies are BT, Cisco Systems, IBM Europe, Intel, Microsoft Europe, Nokia, Nortel Networks, Philips Semiconductors, Siemens AG, Telefónica S.A. and Thales.

The Consortium released a set of Curriculum Guidelines <http://www.career-space.com/cdguide/index.htm>. Part of the Guidelines defines the following set of *Generic Skills Profiles* to be used as reference point modules for Universities to mix and derive their own curricula.

- Software Architecture and Design
- Software and Application Development
- IT Business Consultancy
- Systems Specialist
- Multimedia
- Data Communications Engineering
- Integration & Test / Implementation and Test Engineering
- Product Design
- Communications Network Design
- Technical Support
- Digital Design
- Digital Signal Processing (DSP) Application Design
- Radio Frequency (RF) Engineering

Appendix E: ICT-related Subjects in WA Senior Secondary Schools

Below are subject summaries of current ICT-related Year 11 and Year 12 subjects from Curriculum Council of Western Australia. The descriptions are for the 2002/2003 round. Full lists and details of all subjects are available from the Curriculum Council's web site http://www.curriculum.wa.edu.au/.

All ICT-related subjects listed below are under the learning area *Technology and Enterprise: Business and Computing.* Subjects classified as *Vocational Subjects*, which leads to TAFE or direct injection into the workforce, are not included in our list.

Subject descriptions below are reproduced from http://www.curriculum.wa.edu.au/files/doc/58787_1.doc and http://www.curriculum.wa.edu.au/files/doc/58790_1.doc (accessed 4th October 2002).

We also include a more detailed subject content for *Information Systems E238*. This subject is a Tertiary Entrance Examinations (TEE) subject, where the score can use used in the Tertiary Entrance Score (TES) to derive the Tertiary Entrance Rank (TER) for entry into higher education. The syllabus is listed in http://www.curriculum.wa.edu.au/files/doc/28196_1.doc.

YEAR 11 Subjects:

Technology and Enterprise: Business and Computing:

Business Information Technology - D231

> Students are provided with opportunities to apply computer technology to the development of products that satisfy human communication and information needs. The features of a range of advanced computer applications are introduced with the focus being on using computer technology to solve problems. Whilst the focus is on the use of computer technology, both the processes and the products are emphasised. Students develop generic computer skills and concepts by using a variety of computer technologies.
>
> The focus is on the creation of documents with an emphasis on design, layout and presentation using any or all combinations of text, graphics and presentation applications used in industry, commerce and government occupations.

Digital Media - D236

> Students are provided with opportunities to apply computer technology to the development of products that satisfy human communication and information needs. The features of a range of advanced computer applications are introduced with the focus being on using computer technology to solve problems. Whilst the focus is on the use of computer technology, both the processes and the products are emphasised.
>
> Students develop generic computer skills and concepts by using a variety of computer technologies. Emphasis is placed on the

development, design and production of digital media for various applications.

Information Systems - D238

Modern society is bombarded by vast amounts of information. Information systems play an essential role in the management and provision of this information. This subject will help students identify the need for information systems, and introduce them to the practical skills and theoretical knowledge required for their development and evaluation. Students will be expected to design, implement and evaluate computer based information systems using a variety of productivity and/or programming tools. This subject provides students with a solid basis for further study in a wide range of disciplines.

Personal Information Technology - D233

Students are provided with opportunities to apply computer technology to the development of products that satisfy human communication and information needs. The features of a range of advanced computer applications are introduced with the focus being on using computer technology to solve problems. Whilst the focus is on the use of computer technology, both the processes and the products are emphasised.

Students develop generic computer skills and concepts by using a variety of computer technologies. Emphasis is places on the creative use of computers as productivity tools in a personal context.

Vocational Subjects:

Computer Fundamentals - D705

Students will work individually and in small groups to carry out a range of tasks using the computer to:

- use relevant occupational health and safety practices
- apply recycling techniques and minimise paper waste
- use manuals and on-line help to solve problems
- start-up, use, exit and shut-down a computer
- manage electronic and written files
- create, save and print a word processed document
- design and construct, edit and manipulate data, format and print a spreadsheet
- create a simple database, access an established database, manipulate data and modify the structure of a database
- produce useable reports.

Computerised Accounting - D728

Students will work individually and in groups to operate a microcomputer using accounting software as used in small business.

- use relevant Occupational Health and Safety practices
- apply recycling techniques to minimise paper wastage
- use manuals and on-line help to solve operational problems

- perform functions of the Cash Book component of an accounting software package
  Accounts Receivable
  Accounts Payable
  General Ledger
- apply theory of data entry and application of accounting system.

Keyboard Operations - Application - D744

Students learn keyboarding techniques and operations; develop knowledge and skill levels through a variety of techniques:

- use relevant Occupational Health and Safety Practices
- apply recycling techniques to minimise paper wastage
- use manuals and on-line help to solve operational problems
- produce simple useable business documents using standard format
- identify keyboarding errors
- retrieve and edit simple documents from written text
- name and save documents
- manage electronic and written files.

Keyboard Operations - Technique - D743

Students learn keyboarding techniques and operations, develop knowledge and skill levels through a variety of techniques:

- use relevant Occupational Health and Safety Practices
- apply recycling techniques to minimise paper wastage
- key in data using appropriate techniques for keyboard and numeric keypad
- operate keyboard using typing techniques with designated accuracy
- operate numeric keypad using typing techniques with designated accuracy
- touch type techniques
- identify keyboarding errors
- verify accuracy of data entry
- key in data from straight copy in accordance with accepted Australian Standards 2708-1991.

Computer Fundamentals for Hospitality and Tourism - D920

Students will work individually and in small groups to carry out a range of tasks in the Food, Hospitality and Tourism context using the computer to:

- use manuals and on-line help to solve problems
- start-up, use, exit and shut down a computer
- manage electronic and written files
- create, save and print a word processed document
- use spreadsheets and databases
- connect into information networks.

Computer Assisted Drawing and Design - D734

The Computer Assisted Drawing and Design subject was developed to give the student the opportunity to study a course of technical drawing where the main tool used to produce drawings will be the computer.

The general aims of the subject are to provide the student the opportunity to study a subject which has relevance to the present work environment and gain experience with computers in a specific field of learning.

A CAD program should be introduced early and used to produce technical drawings. Major ideas include:
- freehand sketching
- isometric and oblique drawing
- interpretation of technical drawings
- application of CAD
- links between CAD and CAM.

YEAR 12 Subjects:

Technology and Enterprise: Business and Computing:

Business Information Technology - E231

Students are given the opportunity to develop their skills and knowledge in the use of information technology in a business context. Emphasis is placed on the design and creation of products using a wide range of software. The completion of tasks may encompass a combination of any or all combinations of text, graphics, communications and presentation applications used in business.

The competencies developed will provide valuable skills for further training or general post-secondary studies.

Industry Information Technology - E234

Emphasis focuses on the uses of computers in workplace contexts other than the standard business office. Particular industry contexts will dictate appropriate computer applications. Many industry contexts are possible and suitable applications might include, but would not be limited to, electronic or traditional publishing, CAD/CAM, data logging, robotics and programming environments. In addition, some industry contexts might use specialised applications based on underlying communications and database systems.

Interactive Media - E237

Students acquire skills in the development of interactive media as applied to problems associated with personal, community and industry needs. The subject focuses on user control of interactive media created through the use of authoring environments and tools. Emphasis is on aspects of design and the processes of production rather than on the technical aspects of commercial development.

Information Systems - E238 (TEE Subject - List 2)

Computer based information systems are an integral component of our social structure. This subject will help students analyse, design and develop information systems. Within this framework, students will examine data communication, networks, hardware and software, and the principles of programming. It provides students with a solid basis for further study in a wide range of disciplines.

Vocational Subjects:

Audio and Word Processing Skills - E880

Students will work individually and in groups to develop knowledge and skills in carrying out the following:
- competent use of computer and audio equipment
- use of a word processing program to produce complex documents
- use of a desk-top publishing package
- use of transcribing machine to produce documents.

Computer Fundamentals - E705

- Use relevant Occupational Health and Safety practices
- Maintain audio equipment
- Apply recycling techniques to minimise paper wastage
- Operate audio equipment
- Transcribe pre-recorded text to produce useable paragraphs on keyboard equipment
- Transcribe pre-recorded text with amendments to produce useable paragraphs
- Produce one page business documents from pre-recorded office style dictation
- Use manuals and on-line help to solve operational problems
- Produce useable complex documents using keyboarding skills
- Retrieve, edit and reformat complex documents
- Manipulate existing multi-page documents
- Create and print mail merge documents
- Manage electronic and written files
- Identify integrated software packages, discuss the advantages of utilising the facility which enables data transfer between files and identify possible applications
- Transfer data between word processors, database and spreadsheet documents within an integrated software package
- Produce documents which require the transfer of data between spreadsheet, database and word processor.

Subject content for TEE subject *Information Systems E238*:

Based upon 110 hours of instruction.

Information Systems (35 hours)

1. Define:
   - datum
   - data
   - information
   - system
2. Describe:
   - information systems
   - communications systems
3. Define:
   - carriers
   - service providers
4. Describe:
   - management information systems
   - computer systems
   - computer-based information systems
5. Describe:
   - centralised information systems
   - distributed information systems
6. Describe:
   - open information systems
   - closed information systems
7. Apply logical data flow diagrams.
8. Apply analysis techniques.
9. Apply design techniques including 'life cycle' and 'prototyping'.
10. Define and compare:
   - 'top down' design
   - 'bottom up' development
11. Define project management including:
   - teams
   - planning
   - progress reports
   - time management
   - work assignment (work breakdown structure)

Note: Students are expected to develop skills in the analysis and design of information systems in association with other sections of this subject.

Computer Architecture (10 hours)

1. Describe the fetch-execute cycle.
2. Describe the central processing unit (CPU) components in terms of the functions of:
   - control unit
   - registers
   - arithmetic/logic unit (ALU)
3. Describe the roles of buses.
4. Describe the concepts of caching.
5. Define:
   - reduced instruction set computer (RISC)
   - complex instruction set computer (CISC)
6. Describe:
   - sequential processing
   - parallel processing
   - distributed processing
7. Define:
   - firmware
   - software
8. Define levels of storage.
9. Describe the convergence and compatibility of computer architectures.
10. Describe trouble-shooting procedures.
11. Describe the role of preventive maintenance.

Note: Students are expected to be aware of underlying computer technology in the day-to-day use of computers in various applications.

Data Communications (15 hours)

Communications outside of the PC

1. Define carriers and human communications media including:
   - Public Switched Telephone Network (PSTN)
   - Integrated Services Digital Network (ISDN)
   - radio
   - television
   - cable television
   - interactive media

Transparent technology

1. Describe media including:
   - Data Terminal Equipment (DTE)
   - Data Communications Equipment (DCE)
   - modems
   - bandwidth
   - optical and electronic transmission media, including copper (coaxial, unshielded twisted pair, shielded twisted pair), microwave and laser
2. Describe the role and purpose of standards in achieving connectivity including:
   - RS232
   - ISO 802.3
   - X.25
3. Describe:
   - noise
   - attenuation
   - error detection/correction standards

Networks

1. Define:
   - digital networks
   - ISDN
   - LAN
   - WAN
   - cellular networks
   - International Standards Organisation-Open Systems Interconnectivity (ISO-OSI)
2. Describe the difference between LAN and WAN.
3. Define common problems with network interconnections.
4. Describe the structure of the Internet.
5. Apply the facilities of the Internet to personal communications.
6. Apply an effective search strategy to locate required information on the Internet.
7. Define the role of clients and servers.
8. Define LAN topology.
9. Describe network hardware including:
   - hubs
   - routers
   - bridges
10. Define and compare:
   - distributed information processing
   - centralised information processing
11. Describe:
   - the importance of data security
   - data security techniques (including encryption)
   - how computer-based information systems can encroach upon an individual's privacy
   - application of ethics to the use of information resources

Note: Students are expected to be aware of communications technologies and their interaction, and be able to use network facilities to retrieve information.

Databases (25 hours)

1. Define file organisation for:
   - sequential files
   - random files
   - indexed sequential files (ISAM)
2. Apply relations, attributes, tuples, keys (primary and foreign) and indexing.
3. Describe normalisation to the Third Normal Form (3NF).
4. Describe:
   - data integrity
   - data redundancy
   - data duplication
5. Describe the role of the data dictionary in systems analysis, design and development.
6. Apply entity-relationship diagrams.
7. Define database models:
   - flat-file
   - hierarchical
   - network
   - relational

Note: Students are expected to develop skills in using a relational database and apply these skills to modify and to build simple computer-based information systems.

Languages (25 hours)

1. Define:
   - machine code
   - assembler languages
   - procedural languages
   - fourth generation languages (4GL)
2. Define and compare:
   - interpreters
   - compilers
3. Apply:
   - sequence
   - selection
   - iteration
4. Apply modular principles and simple parameter-passing.
5. Apply data structures, including simple arrays and records.
6. Apply Pseudocode and Nassi-Shneiderman diagrams to solve simple problems.
7. Apply programming to solve simple problems.

Note: Students are expected to understand these principles common to languages in a variety of contexts, rather than to learn a specific language.

Appendix F: Major Listings of ICT Careers and Professions

Department of Employment and Workplace Relations (DEWR) Careers Classifications

Reproduced from Department of Employment and Workplace Relations' Job Outlook web-site http://jobsearch.gov.au/joboutlook/OccCatSearch.asp (accessed 30th September 2002).

Statement on classifications from web site: "*This classification structure is based mainly on the Australian Standard Classification of Occupations Second Edition (ASCO2), developed jointly by the Australian Bureau of Statistics (ABS) and the Department of Employment and Workplace Relations (DEWR)… Additional IT occupations have recently been added to provide for new and emerging skills and occupations for 'Computing Professionals'.* "

Computing and IT:

- IT Business Specialists
    - IT Account Manager
    - IT Business Analyst
    - IT Consultant
    - IT Trainer
    - IT Writer/Documentor
- IT Management
    - IT Development Manager
    - IT Manager - Service, Product, Test, Operations
    - IT Project Manager, Team Leader
- IT Operations
    - IT Database Administrator
    - IT Help Desk
    - IT Network Administrator
    - IT Operator
    - IT Support IT Systems Administrator
- IT Other Occupations
    - IT Computer Animation
    - IT Desktop Publishing
    - IT Other Occupations
- IT Systems Analysis and Design
    - IT Auditor
    - IT Database Analyst/Data Modellor
    - IT Design Specialist, Network Analyst
    - IT Quality Specialist
    - IT Security Specialist
    - IT Systems Analyst
- IT Systems Development
    - IT Analyst/Programmer
    - IT Data Warehouse Developer
    - IT Database Developer
    - IT Developer/Applications Programmer
    - IT Multimedia Developer
    - IT Tester
    - IT Web Developer
- IT Technical/Engineer

- IT Architect/Network/Software
- IT Communications Specialist
- IT Hardware/System Engineer
- IT Network Engineer
- IT Software Engineer
- IT Technician (Hardware)

ACS' IT Careers Portal

List of IT careers from the Australian Computer Society *IT Careers Portal* web site http://www.itcareers.acs.org.au/careers/ (accessed 19th September 2002):

BUSINESS ANALYSIS
- Business Analyst
- Business Systems Analyst
- Business Systems Planners
- Principal Solutions Architect

COMPUTER ENGINEERING
- Computer Engineer Repair / Service Engineer
- Electronics Engineer Customer Engineer
- Hardware Design Engineer Technical Support Engineer
- Computer Systems Engineer Computer Service Engineer
- Customer Engineer

CONSULTING AND CONTRACTING
- Principal Consultant
- Consultant Associate
- Corporate Professional Services Manager
- Professional Services Manager
- Senior Consultant
- Consultant
- IT Contractor

CUSTOMER CONTACT CENTRES
- Telesales Manager
- Teleseller (Inbound)
- Telesales Representative
- Telephone Support Specialist
- Telemarketing Administrator
- Teleseller (Canvasser)
- Customer Support Manager
- Call Dispatch Operator
- Corporate Customer Support Manager

DATABASE ADMINISTRATION
- Database Administrator

FINANCE AND ADMINISTRATION
- Financial / Management Accountant
- Corporate Finance & Administration Manager
- Divisional Financial Controller
- Contracts Administration Manager
- Business Assurance Analyst
- Warehouse & Distribution Manager
- Corporate Logistics Manager
- Chief Accountant
- Payroll Manager
- Administration Officer
- Contracts Administrator
- Logistics Manager
- Facilities Manager
- Administration Manager

IT HELP DESK
- Customer Support Manager
- Telephone Support Specialist
- Senior Telephone Support Specialist
- Trainee Support Specialist

INTERNET AND E-COMMERCE CAREERS
- Web Programmer
- Web Architect

- Internet / Intranet Administrator
- E-Commerce Project Manager
- Web Designer
- Intranet Engineer
- Online Producer
- E-Commerce Architect
- E-Commerce Programmer
- Web Administrator

IT EDUCATOR
- Lecturer
- Education Manager
- Customer Education Manager
- Senior Customer Training Officer
- Training Consultant
- Training Officer
- Customer Training Officer
- Senior Training Officer

MULTIMEDIA
- Writer
- Web Programmer
- Copywriter
- Online Producer
- Multimedia Content Author
- Multimedia Graphic Designer
- Website Designer

NETWORK SUPPORT CAREERS
- Network Manager
- Network Support Analyst
- Senior Network Support Analyst

PROJECT MANAGER
- Project Leader
- Project Manager
- Project Director

SALES AND MARKETING
- Sales Representatives
- Regional Sales Manager
- Channel Sales Manager
- Account Manager
- Marketing Analyst
- Marketing Manager
- Corporate Sales & Marketing Manager
- Marketing Communications Officer
- Communications Manager
- Public Relations Manager

SOFTWARE DEVELOPMENT
- Computer Systems Officer
- Application Programmer
- Software Engineer
- Design Technician / Specialist (R&D)
- Programmer
- Systems Programmer
- Analyst Programmer
- Senior Programmer

SYSTEMS ANALYSIS & DESIGN CAREERS
- Network Designer
- Systems Analyst
- Solutions Architect
- Senior Systems Engineer
- Senior Solutions Architect
- Systems Architect
- Principal Solutions Architect

SYSTEMS MANAGEMENT & ADMINISTRATION
- Data Communications Consultant
- Network Administrator
- LAN/WAN Administrator
- Database Administrator
- Network Support Analyst
- Systems Administrator
- Network Manager
- Network Engineer
- Systems Administration Analyst

OTHER AREAS
- Computer Scientist
- Information Systems Management
- Telecommunications
- Electronic Data Processing (EDP) Auditor

NWCET Information technology skill standards

The Northwest Center for Emerging Technology (NWCET) developed a list of IT skills standards based on eight career clusters. The following is the job titles in the eight career clusters, reproduced from Lopez-Bassols (2002, page 32-33).

Database administration and development:
- Data administrator
- Data analyst
- Data architect
- Data management associate
- Data modeler
- Data modelling specialist
- Database administration associate
- Database administrator
- Database analyst
- Database developer
- Database manager
- Database modeler
- Database security expert
- Decision Support Services (DSS)
- Knowledge architect
- Senior database administrator
- Systems analyst
- Tester

Digital media:
- 2D/3D artist
- Animator
- Audio/video engineer
- Designer
- Media specialist
- Media/instructional designer
- Multimedia author
- Multimedia authoring specialist
- Multimedia developer
- Multimedia specialist
- Producer
- Production assistant
- Programmer
- Streaming media specialist
- Virtual reality specialist
- Web designer
- Web producer
- Web specialist

Enterprise systems analysis and integration:
- Application integrator
- Business continuity analyst
- Cross-enterprise integrator
- Data systems designer
- Data systems manager
- Data warehouse designer
- E-business specialist
- Electronic transactions implementer
- Information systems architect
- Information systems planner
- Systems analyst
- Systems integrator

Network design and administration:
- Communications analyst
- Data communications analyst
- Information systems operator
- Information technology engineer
- Network administrator
- Network analyst
- Network architect
- Network engineer
- Network manager
- Network operations analyst
- Network security analyst
- Network specialist
- Network technician
- Network transport administrator
- PC support specialist
- PC network engineer
- Systems administrator
- Systems engineer
- Technical support specialist
- User support specialist

Programming/software engineering:
- Applications analyst
- Applications engineer
- Business analyst
- Computer engineer
- Data modeler
- Operating system designer/engineer
- Operating system programmer/analyst
- Programme manager
- Programmer/analyst
- Project lead
- Software applications specialist

- Software architect
- Software design engineer
- Software design engineer and tester
- Software development engineer
- Software QA specialist
- Software tester
- Systems analyst
- Systems administrator
- Test engineer
- Tester

Technical support:
- Analyst
- Call centre support representative
- Content manager
- Customer liaison
- Customer service representative
- Customer support professional
- Help desk specialist
- Help desk technician
- Senior systems analyst
- Systems analyst
- Technical account manager
- Technical support engineer
- Technical support representative
- Testing engineer

Technical writing:
- Desktop publisher
- Document specialist
- Editor
- Electronic publications specialist
- Electronic publisher
- Instructional designer
- Online publisher
- Technical communicator
- Technical editor
- Technical publications manager
- Technical writer

Web development and administration:
- Web administrator
- Web architect
- Web designer
- Web page developer
- Web site developer
- Web specialist
- Webmaster

US Bureau of Labor Statistics' Career Guide to Computer and Data Processing Services

The following is reproduced from the United States Department of Commerce Bureau of Labor Statistics' Careers Guide to Industries web site, http://www.bls.gov/oco/cg/cgs033.htm#occupations:

Programmers *write, test, and maintain the detailed instructions, called programs or software, that computers must follow to perform their functions. These programs tell the computer what to do, such as which information to identify and access, how to process it, and what equipment to use. Programmers write these commands by breaking down each step into a logical series, converting specifications into a language the computer understands. While some still work with traditional programming languages like COBOL, object-oriented programming languages, such as C++ and Java, computer-aided software engineering (CASE) tools, and artificial intelligence shells now are being used to create and maintain programs. These languages and tools allow portions of code to be reused in programs that require similar routines. Many programmers also customize a package to clients' specific needs or create better packages.*

Computer engineers *design, develop, test, and evaluate computer hardware and related equipment, software programs, and systems. Although programmers write and support programs in new languages, much of the design and development now is the responsibility of software engineers or software developers.* ***Software engineers*** *must possess strong programming skills, but are more concerned with developing algorithms and analyzing and solving programming problems than with actually writing code. These professionals develop many types of software, including operating systems software, network distribution*

software, and a variety of applications software. ***Computer systems software engineers*** *coordinate the construction and maintenance of a company's computer systems, and plan their future growth. They develop software systems for control and automation in manufacturing, business, and other areas. They research, design, and test operating system software, compilers—software that converts programs for faster processing—and network distribution software.* ***Computer applications software engineers*** *analyze users' needs and design, create, and modify general computer applications software or specialized utility programs. They analyze user needs and develop software solutions.* ***Computer hardware engineers*** *, on the other hand, usually design, develop, and test computer hardware, such as computer chips, and supervise its manufacture and installation. One of the goals of computer hardware engineering is to design and produce computing devices that function efficiently and economically.*

Professionals involved in analyzing and solving problems include ***systems analysts****, who study business, scientific, or engineering data processing problems and design new flows of information. Computers need to be connected to each other and to a control server to allow communication among users, thus enhancing use of their computing power. Systems analysts tie together hardware and software to give an organization the maximum benefit from its investment in machines, personnel, and business processes. To do this, they may design entirely new systems or add a single new software application to harness more of the computer's power. They use data modeling, structured analysis, information engineering, and other methods. Systems analysts prepare charts for programmers to follow for proper coding and also perform cost-benefit analyses to help management evaluate the system. They ensure that the system performs to its specifications and test it thoroughly.*

Database administrators *determine ways to organize and store data and work with database management systems software. They set up computer databases and test and coordinate changes to them. Because they also may be responsible for design implementation and system security, database administrators often plan and coordinate security measures.*

Computer and information scientists *work as theorists, researchers, or inventors. They apply a higher level of theoretical expertise and innovation and develop solutions to complex problems relating to computer hardware and software.*

Computer support specialists *provide technical assistance, support, and advice to customers and users. This group of occupations includes workers with a variety of titles, such as* ***technical support specialists*** *and* ***help-desk technicians****. These troubleshooters interpret problems, and provide technical support for hardware, software, and systems. Support specialists may work either within a company or other organization or directly for a computer hardware and software vendor. They answer phone calls, analyze problems using automated diagnostic programs, and resolve recurrent difficulties encountered by users.*

Other computer specialists include a wide range of related professionals who specialize in operation, analysis, education, application, or design for a particular piece of the system. Many are involved in the design, testing, and evaluation of network systems such as local area networks (LAN), wide area networks (WAN), Internet, and other data communications systems. Specialty occupations reflect an emphasis on client-server applications and end-user support; however, occupational titles shift rapidly to reflect new developments in technology.

Appendix G: Current ICT Skills Shortages in Australia

Reproduced from Department of Employment and Workplace Relations' October 2002 Skills Shortage List for ICT. Available at http://www.workplace.gov.au/WP/Content/Files/WP/EmploymentPublications/NSS_2002.xls (accessed 4th November 2002).

ICT SPECIALISATION	AUST	NSW	VIC	QLD	SA	WA	TAS	ACT
* S = Shortage D = Recruitment Difficulty								
Database								
DB2		D		D		D		
Oracle		D		D	D	D		
Microsoft SQL Server		D			D		D	
Sybase SQL Server		D		D	S	D		D
General Application Development/Software Engineering								
PowerBuilder		D		S	D	D		D
Java				D	D	D	D	D
Java Script					D			
C++				D	D		D	D
Delphi		D	D	D	D	D		
Lotus Notes		D		D	D	D	D	D
Progress	S	S	D	S	D	D	D	
Powerhouse		D		S	D	D		
Internet, Networking/Lan/WAN								
IPX		D				D		
SNA		D			D			
Advanced Web Design				D	D	D		
ASP						D		
Firewall/Internet security		D		D	D	D		D
Xml				D	D	D		
Java Security and electronic commerce	S	D	D	D	S	S		D
Multimedia								
Multimedia					D			
Office/E-mail/Groupware								
Groupwise				D	D	D		
Lotus Notes				D	D	D		
Client/Server applications								
COBOL					D	D		
SAP		S		D	D	D		D
PeopleSoft	S	S	D	D	S	S		
Siebel	S	D	D	S	S	D		
System Software Support								
Data Warehousing		D	D	S	D	D		D
Operating Systems								
Unix		D		D	D			
Solaris		D		D	D	D		
Linux		D		D				
HP-UX		D		D	D	D		
VMS		D		D		D		

ICT SPECIALISATION	AUST	NSW	VIC	QLD	SA	WA	TAS	ACT
* S = Shortage D = Recruitment Difficulty								
Communications								
Radio				D	D	D		
SDH				D		D		
WDM		D		D		D		
GSM				D		D		
CDMA				D	D	D		
Broadband CDMA		D		D		D		
Satellite design		S		D	D	D		
TDMA		D		D		D		
VSAT		D		D		D		
Photonics		D	D			D		
Process & Systems management								
Project Management								D
Systems analysis						D		
Broad commercial business understanding		D						
E-Commerce (eg business/financial management/analysis/customer service)								
e-commerce security (non programming)		D	D	D	S	D		D
Security								
Network Security		D		D	D	D		D
Risk Management		D		D	D	D		
CISSP*	S	D	D	S	D	S		D
PKI		D	D	D	D	D		
Other specialisations not listed above (eg GIS, Mapinfo)								
IDMS					S			
ADA in Defence					D			
Visual C++					D			
Hi Level Cool-Gen								D
Mapinfo		D		D	S	D		
MIMS/Ellipse				S				
IBM Mainframe						D		
Pro IV						D		
Test Analyst								D

Source: Reproduced from
http://www.workplace.gov.au/WP/Content/Files/WP/EmploymentPublications/NSS_2002.xls

Appendix H: ARC Priority Areas Funding 2003 - Outcomes

The following are tables showing outcomes of applications to Priority Areas in the Australian Research Council's (ARC) National Competitive Grants Programme (NCGP) 2003 Round. The two priority areas with some relevance to ICT are:

- Complex / Intelligent Systems, and
- Photon Science and Technology

Further details can be found at
http://www.arc.gov.au/ncgp/outcomes/default.htm.

Success Rates:

Table 1: Discovery-Projects applications recommended for funding

Priority Area	Priority Applications	
	Number recommended	Success Rate
Complex / Intelligent Systems	40	31.3%
Genome / Phenome Research	97	32.8%
Nano- and Bio- materials	79	33.2%
Photon Science and Technology	45	32.6%
Not in priority areas	660	23.8%
Overall	**921**	**25.8%**

Table 2: Linkage-Projects Round One applications recommended for funding

Priority Area	Priority Applications	
	Number recommended	Success Rate
Complex / Intelligent Systems	18	52.9%
Genome / Phenome Research	12	48.0%
Nano- and Bio- materials	16	59.3%
Photon Science and Technology	8	72.7%
Not in priority areas	271	48.0%
Overall	**325**	**49.2%**

Funding for the Designated Priority Areas:

Table 5: Discovery-Projects recommended allocations 2003-2007

Priority Area	Priority applications
Complex / Intelligent Systems	$9,309,968
Genome / Phenome Research	$27,863,585
Nano- and Bio- materials	$18,336,222
Photon Science and Technology	$15,803,212
Total in Priority Areas	**$71,312,986**

Table 6: Linkage-Projects Round One recommended allocations 2003-2007

Priority Area	Priority Applications
Complex / Intelligent Systems	$3,451,814
Genome / Phenome Research	$2,542,526
Nano- and Bio- materials	$2,364,765
Photon Science and Technology	$2,081,574
Total in Priority Areas	**$10,440,678**

Appendix I: Student Enrolment Statistics for Australian Tertiary Degrees

The following are tables reproduced from Department of Education, Science and Training's *Students 2001: Selected Higher Education Statistics*, available at http://www.dest.gov.au/highered/statistics/students/01/tables.htm (accessed 30th September 2002):

Table 27: All Students by Level of Course, Broad Field of Education and Gender, 2001

Table 32: All Students by State, Institution and Broad Field of Education, 2001

Table 56: Actual Student Load (EFTSU) for All Students by Narrow Discipline Group and Broad Level of Course, 2001

Table 58: Actual Student Load (EFTSU) for All Students by State, Institution and Broad Discipline Group, 2001 (a)

In the tables, ICT areas are mainly grouped under the Field of Education *Information Technology*.