Human Resource Development for Knowledge Based Economies: a changing role for universities

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2. Introduction: knowledge systems as systems of collaboration

Discussion and debate concerning university and industry collaboration for the production of knowledge is not new. In the UK the problem of making universities more responsive to the needs of industry was a subject of parliamentary debate at least 100 years ago. What is new, however, are the environments in which such collaboration takes place, the growing emphasis on producing skills and knowledge to support ‘knowledge-based economies’ and the structure of relationships between institutions and industry sectors for producing and diffusing knowledge.

Universities and industrial enterprises now operate in institutional environments where knowledge and intellectual property are critical factors in economic development. Increasing global competition has meant that innovation, market-niche, standard setting and quality control have become even more critical success factors, not only for firms but also for universities. In ‘globalised’ economies where materials and energy are comparatively cheap and capital is mobile, it is knowledge, embedded in human capital and technology, that are defining factors in international competitiveness. Industrial enterprises around the world have responded to these developments by seeking to embed themselves in partnerships, to gain access to increasingly dispersed ‘knowledge resources. Through collaborative alliances, knowledge based firms have sought to ensure a flow of capabilities, rather than simply a flow of capital, or raw materials. As Gibbons et al have put it,

… the source of value-added lies in the precise form which the collaboration of groups and the experience and skills of its members take.\(^2\)

In a less obvious, but equally pervasive development, universities have responded in similar ways. They have also become embedded in complex sets of organisational alliances. In some cases collaboration has been comparatively exclusive with only a small number of organisations or institutions involved. In other cases they have been far more inclusive and developed complex webs of collaborative activity. While some observers have emphasised the salience of national boundaries in containing these collaborative networks\(^3\), others have drawn attention to the growing emergence of transnational

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1 S.K. Bhattacharyya, ‘University-Industry Relations in the 21st Century’ Keynote speech to the Bangkok APEC research project on Modalities of University-Industry Cooperation in the APEC Region, Thailand Ministry of University Affairs, April, 1996.


3 Gibbons *et al*
alignances that transcend national economies. In both national and international contexts it is the emerging systemic nature of alliances that is radically transforming production-based economies to knowledge-based economies. Understanding ‘knowledge systems’ or ‘knowledge societies’ rather than ‘production systems’ is therefore a critical task for understanding ‘knowledge based collaboration.

Essentially a knowledge system describes a ‘structured’ arrangement of institutions, communities and organisations that intersect through the production, use and diffusion of knowledge. The idea of a knowledge system and an innovation system is sometimes used interchangeably in the literature. However, knowledge systems underpin systems of innovation. A knowledge system may not necessarily be innovative. But an innovation system is inherently dependent on access to a knowledge system or systems. The idea of a knowledge system is also important because an innovation system is often misunderstood as being primarily concerned with only technological aspects of innovation. While a knowledge system emphasises technological innovation it also emphasises the whole range of knowledge producing and diffusing capabilities that enable innovation to proceed.

A knowledge-based economy requires a dynamic and sustainable knowledge-system to feed industrial development. The extent to which a knowledge system can be creative, productive and sustainable depends on the extent to which the components of the system are well linked or ‘institutionalised’. The great fragility of many local knowledge systems, particularly those in developing countries, is a direct result of their being ‘weakly institutionalised’. This is not simply a matter of size or age of the systems. Rather, it is a matter of the systematic nature and sustainability of interaction between the elements that make up the system. A knowledge-system can therefore be understood as a ‘system of collaboration’. Collaboration between training institutions, such as universities and colleges and industry is an important component of such a system.

Successful and long-term industry and university collaboration does not just involve universities and industrial enterprises. It involves a wide range of facilitating and supporting institutions - of which universities are just one. Where, and how do they contribute to the knowledge systems that underpin knowledge-based industries? How are they most successfully embedded or institutionalised?

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5 See Nico Stehr for a comprehensive critique of the concept of ‘knowledge societies’. *Knowledge Societies*, Sage, London, 1994. Among the key characteristics that identify a knowledge society, according to Stehr are: the deep penetration of scientific knowledge into most spheres of economic and social activity and increased dependence on a stratum of ‘experts’ advisors, counselors and institutions based on deploying specialised knowledge

2. **Higher education and industry collaboration: an international perspective**

Successful collaborative practices between universities and industry in dynamic knowledge systems elsewhere in the world share at least one common feature. That is, that industry, universities, ‘facilitating agencies’ and various levels of government are becoming intertwined in ‘institutionalised’ structures for collaboration. It is important to note, however, that these structures, are not simply organisational amalgamations or syntheses. Rather, they emphasise, indeed depend on, quite different roles and modes of operation of the constituent units. This creates interesting challenges for the ways universities define their role in the innovation processes.

This paper seeks to illustrate the extent to which universities becoming embedded in such knowledge systems in various parts of the world. We then focus on the Australian experience in inter-organisational collaboration and innovation and discuss some key challenges for human resource development in knowledge-based industries in Australia.

**Examples of knowledge-based collaboration in Canada**

**Saskatchewan**

In Canada the Saskatchewan region has undergone a major industrial transformation from a predominantly prairie based economy, to one dependent on the production and application of scientific knowledge. Through the past two decades an agricultural biotechnology industry has emerged that is now regarded as the most important centre for agricultural biotechnology in Canada. Universities and public sector agencies have been key institutions in bringing about the transformation. There were few private sector firms in the region in the 1970s. Entrepreneurs who were the founders of the new biotechnology based firms emerged from the public sector, many of whom were from the University of Saskatchewan. However, it is important to note that the initial impetus for creating spin-off firms was maintained through a number of newly created support agencies and institutions. These contributed to a concentration of human resources appropriate for the knowledge intensive industrial development that was underway.

Joint funding from research councils, the university and the private sector contributed to an expansion of industry liaison activity and increased the effectiveness of the technology transfer offices at both the University of Saskatchewan and the University of Regina. Ongoing collaboration and skills development have become more institutionalised recently with the introduction of an industry/university cooperative undergraduate teaching program.

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**The Okanagan Valley (‘Silicon Vineyard’)**

While, Saskatoon has become well know internationally as a ‘high tech community’ other regions in Canada have set out to foster similar knowledge-based development.. One of these smaller successful developments reflect similar collaborative processes and the emergence of a localised knowledge system.

The Okanagan valley, often referred to as the ‘silicon vineyard’, in the interior of British Columbia has been promoted as a ‘technology-based’ community’. University and industry cooperation while following different path from the Saskatoon experience is becoming an increasingly important component in the region’s development. Key components in the system include the Okanagan High Technology council (comprising a group of industry executives, academics, research institutions, government leaders and resource agencies. The council sponsors projects concerned with human resource development, promoting research and development partnerships, and serves as a liaison between ‘the technology industry and Okanagan’s communities’. The Okanagan University College has developed a Technology Access Centre for promoting partnerships in research and training. An interesting development is that the British Columbia Science Council and the National Research Council have both established offices at the Centre. The Centre also offers support for new companies working directly with faculty staff on development programs.

According to developers in the region the main issue for building their technology industries was to create an environment to attract and retain skills for both technology and business development. The Federal government operates the Summerland agricultural research station that now provides food processing laboratory facilities and research training and a source of employment for graduates. Currently around 500 firms, mainly engaged in software development, environmental engineering, aerospace and internet services complement traditional industries associated with agriculture and forestry.

**The Ottawa Carlton** region in Canada provides an example of a more complex and diverse system. The IT business sector took a leading role in establishing its own network or consortia and organizations as a source of entrepreneurs to lead economic growth in the region. Various other actors and agencies, including the universities, have contributed substantially to this process; a process which has been aided by a high degree of mobility and exchange among researchers and faculty at each of the three sets of R&D institutions: universities, industry and the federal labs. Non-profit, private sector catalyst organizations such as the Ottawa-Carleton Research Institute (OCRI) have found this regional economic context conducive to the development of a dense social web permitting ever more communication and interaction among the relevant actors. Into this landscape has flowed ample public sector funding to support world-class research. Essentially the business sector provided the impetus for collaborative development in this

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region. However, the public sector and universities have been essential players in achieving a critical ‘knowledge mass’ and international reputation.

**Examples of knowledge-based collaboration in the US**

*The North Carolina research triangle*

The North Carolina research triangle exemplifies a region where university, industry and government have collaborated to create a dynamic technology based economy - one of the fastest growing in the nation. Three universities: North Carolina State, Duke and NCU, Chapel Hill provide an academic base for industrial collaboration. Each of these universities has a different academic profile and different historical missions. Through the past few years the three universities in the triangle attracted over US$400 million annually in sponsored research. The economic development in the region, regarded as the nation’s ‘Entrepreneurial Hot Spot’ has been has been attributed directly to effective organisational partnerships.

Once again, the partnership that exists between these and other local universities and colleges, local and state government, and the business sector has proven to be an effective tool in many ways for the region.⁹

High research expenditure in both public and private sectors contributes to and is a product of high skills concentrations and retention. Recent census data show that the triangle has the highest concentration of residents with Masters or Doctoral qualifications in the United States – and is growing. A feature of the development and contributing to the sustained nature of organisational partnerships in the Research Triangle has been the role carried out by intermediary agencies. The following summaries illustrate the institutions and organisations that are inextricably interwoven with university industry collaborative arrangement.

*North Carolina’s Industrial Extension Service*

In 1955, the North Carolina General Assembly established the Industrial Extension Service (IES), the first in the nation, at North Carolina State University’s College of Engineering. IES provides practical engineering and industrial management assistance, conducts applied research, advocates industrial use of technology and modern management practices, as well as provides continuing education/training to business, industry, entrepreneurs, engineers, and local governments. As an affiliate of the North Carolina Alliance for Competitive Technologies (NC ACTs), IES collaborates with other state service providers to offer more comprehensive services. Major service programs of IES (most in partnership with other organizations) include: manufacturing engineering and management, plastics processing, and furniture.

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**North Carolina Alliance for Competitive Technologies**

The North Carolina Alliance for Competitive Technologies (NC ACTs) serves as the State of North Carolina’s brokering/matchmaker/linking mechanism for collaboration among and between government, industry and higher education institutions. Serving both as the statewide strategic planning organization for technology-based economic development and the matchmaker to address specific opportunities and issues enables the organization to have a long term perspective within which it facilitates short term actions consistent with this overall vision. Working with specific industries to help them develop competitiveness strategies is another way in which university-industry linkages have been identified, developed, and collaboration resulted. Finally, the organization identifies and mobilizes resources to support sustained industry-university action. The nature and function of the organization enables it to foster business-university interaction through a somewhat unique model and approach.

**Southern Technology Council**

Collaboration between the Southern State Governments has been influential in NC triangle development. The Southern Technology Council was created through an alliance of 14 US Southern States (including Puerto Rico) in 1986. The mission of the council is to strengthen the regional economy through technology. Their strategy for achieving this has been to foster collaboration and partnerships – in particular partnerships between industry and universities.

While technology is a mechanism through which the council seeks to promote economic development, their strategy is built around knowledge ‘use’ and ‘management’ rather than production. This approach is reflected in their four programs:

- **Industrial modernisation and extension** – developing and disseminating information tools and extension programs to support them;
- **R&D infrastructure and technology transfer** - investigating technology transfer processes and performance;
- **Entrepreneurial development** - developing best-practice approaches for establishing new, technology-based enterprises; and
- **Workforce development** – which examines structural change in education and training for improving the quality of new entrants to knowledge based industries.

**Technology: Education and Commercialization Program (TEC)**

The North Carolina TEC program seeks to bridge what they describe as the gap between technology and business capabilities. They seek to achieve this through merging the expertise and experience of NC State’s College of Engineering, the College of Management and professional experience from industrial and venture communities. The TEC program has three key foci: education, technology commercialisation in practice; and research for developing improved methods for education and technology commercialisation. It serves to provide a training ground for professionals, produce practical commercial outcomes, but also provides an action oriented research program for
developing a deeper understanding of innovation and collaborative technology based partnerships.

3. **A review of knowledge-based collaboration in Australia:**

*Introduction*

In Australia, there has been a significant restructuring of the higher education system and the federal government has introduced a range of programs and incentives designed to improve links between universities and industry for underpinning knowledge-based economic development. These programs are directed toward supporting a variety of cooperative mechanisms as well as seeking to improve the general cooperative environment.

Current Australian initiatives to promote industry–university links are based on a continuum of measures. These began with the development of industry-technology arrangements to strengthen industrial R&D, continued with the restructuring of industry-public sector research organisation relationships and are now focused on providing a structural and organisational basis for university–industry (and government research institute) collaboration and linkages.

Some government-led incentives focus on involving industry more directly in the planning, development and implementation of teaching courses and some focus more on increasing industry–university research cooperation. Others aim to raise the level of R&D investment and innovation in the business sector with a flow-on effect of increasing consulting arrangements between universities and innovating firms. Although some observers have suggested there is now an overlap between government R&D incentive programs (Industry Commission, 1995) other studies have argued that the growing interdependency of modes and mechanisms for cooperation depends on this diversity (NBEET, 1993, 1996; DIST, 1995:9).

The modes and mechanisms that generate human resource development for knowledge-based industries in Australia need to be understood in the context of the local industry structure and the extensive reforms that have taken place in the Australian higher education system over the past decade. The present Australian case study reviews these different levels of cooperation and the mechanisms that support them.

*The Australian higher education sector*

The environment in which higher education institutions and industries interact in Australia has changed dramatically during the past decade. While links between the sectors have existed for some time, in the past they have tended to be intermittent and generally unsupported by wider institutional structures. Cooperation, involving activities such as research, training and consultancy services, has now become more frequent and more formalised as industries have found an increasing competitive advantage in relationships with universities. At the same time, higher education institutions have become generally more vocational in response to increasing demands for services and
training, as well as in response to a more strongly competitive research funding environment.

Australian higher education has been influenced predominantly by models from the United States and Great Britain. This is in part because Australia’s earlier universities were influenced strongly by British models, and also in part because many Australian academics have postgraduate qualifications from Britain and the US. There are however, some notable differences. The student profile encompasses a much broader age range than in either the US or Britain. The length of a generalist degree is a year shorter than in the US and broader ranging than its British counterpart. Further, a larger number of diploma and graduate diploma courses are offered in Australian universities compared to their US and British counterparts.10

Since 1987, there has been a substantial restructuring of Australian Higher Education. The binary system (colleges of advanced education and universities) which prevailed over a twenty-three year period from 1965 to 1988 was replaced in 1989 by a Unified National System (UNS). Now, almost all of the 45 previous ‘teaching-only’ colleges have been integrated with universities, and funded to carry out both teaching and research activities.

Changing patterns of study (update figures and include years 1993 - 1998/9)
There are around 490,000 equivalent full-time students in the Australian university system. Numbers vary between institutions from a maximum of nearly 31,000 EFTSU (Equivalent Full-Time Student Unit Load) down to just under 3,000 EFTSU at the smallest institution (DEETYA, 1996).

Growth in higher education during the 1980s is perhaps the most obvious feature of change during the past decade. A notable feature of the increase, however, is the disproportionate growth in some fields of study, shown in Table 1. Among the highest growth areas are fields associated with industry professions: business, nursing, and engineering. Between 1982 and 1992 annual student enrollments in business increased by 97%; engineering enrollments by 68%; and nursing enrollments increased twelve-fold, due to the transfer of nursing education from hospitals to universities. Humanities and the social sciences have also shown significant growth, while the physical, agricultural and medical sciences have grown at a more modest rate.

While these figures illustrate the general growth in the system and structural changes such as the amalgamations of previous colleges of advanced education with universities, they also show that the most significant growth has been in areas where knowledge intensive industries have a special interest in the nature of the courses being offered. These data reflect a more vocationally oriented university system and, as the case studies described in this study show, they reflect a trend toward more structured cooperative relationships between universities and industry.

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Table 1  
Total Students by Broad Field of Study, 1982-1999?

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</thead>
<tbody>
<tr>
<td>1984</td>
<td>64,191</td>
<td>11,296</td>
<td>2,865</td>
<td>22,878</td>
<td>45,667</td>
<td>73,551</td>
<td>28,398</td>
<td>89,441</td>
<td>6,399</td>
<td>7,905</td>
<td>1,450</td>
</tr>
<tr>
<td>1985</td>
<td>67,229</td>
<td>11,128</td>
<td>5,433</td>
<td>23,327</td>
<td>47,275</td>
<td>75,050</td>
<td>28,418</td>
<td>92,814</td>
<td>6,633</td>
<td>7,988</td>
<td>1,435</td>
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<tr>
<td>1986</td>
<td>72,688</td>
<td>11,345</td>
<td>13,222</td>
<td>25,389</td>
<td>56,021</td>
<td>72,616</td>
<td>30,098</td>
<td>101,702</td>
<td>7,061</td>
<td>8,974</td>
<td>1,494</td>
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<tr>
<td>1987</td>
<td>80,700</td>
<td>11,124</td>
<td>17,505</td>
<td>25,389</td>
<td>60,705</td>
<td>72,578</td>
<td>33,178</td>
<td>101,495</td>
<td>7,656</td>
<td>9,323</td>
<td>1,526</td>
</tr>
<tr>
<td>1988</td>
<td>91,592</td>
<td>11,693</td>
<td>21,484</td>
<td>26,712</td>
<td>72,112</td>
<td>72,616</td>
<td>31,153</td>
<td>109,551</td>
<td>8,559</td>
<td>10,724</td>
<td>1,534</td>
</tr>
<tr>
<td>1990</td>
<td>112,666</td>
<td>16,313</td>
<td>31,196</td>
<td>30,679</td>
<td>75,961</td>
<td>79,598</td>
<td>40,207</td>
<td>121,353</td>
<td>9,876</td>
<td>11,243</td>
<td>1,612</td>
</tr>
<tr>
<td>1991</td>
<td>117,104</td>
<td>18,001</td>
<td>34,437</td>
<td>32,744</td>
<td>80,690</td>
<td>80,091</td>
<td>43,599</td>
<td>125,040</td>
<td>11,894</td>
<td>11,842</td>
<td>1,682</td>
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<tr>
<td>1992</td>
<td>122,318</td>
<td>21,236</td>
<td>70,885</td>
<td>86,103</td>
<td>72,314</td>
<td>72,112</td>
<td>47,147</td>
<td>132,935</td>
<td>12,998</td>
<td>1,690</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>129,177</td>
<td>23,490</td>
<td>72,137</td>
<td>88,173</td>
<td>70,635</td>
<td>70,025</td>
<td>48,169</td>
<td>139,365</td>
<td>11,850</td>
<td>13,550</td>
<td>1,674</td>
</tr>
<tr>
<td>1994</td>
<td>143,582</td>
<td>25,000</td>
<td>73,262</td>
<td>91,986</td>
<td>70,525</td>
<td>72,616</td>
<td>48,753</td>
<td>146,308</td>
<td>14,704</td>
<td>1,658</td>
<td></td>
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<tr>
<td>1995</td>
<td>161,072</td>
<td>30,502</td>
<td>75,161</td>
<td>103,701</td>
<td>73,352</td>
<td>50,013</td>
<td>164,861</td>
<td>12,137</td>
<td>15,187</td>
<td>1,639</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>170,887</td>
<td>32,008</td>
<td>77,083</td>
<td>105,860</td>
<td>73,254</td>
<td>49,392</td>
<td>164,823</td>
<td>11,865</td>
<td>15,369</td>
<td>1,706</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>168,100</td>
<td>33,699</td>
<td>77,710</td>
<td>111,204</td>
<td>72,523</td>
<td>50,555</td>
<td>168,100</td>
<td>11,515</td>
<td>15,445</td>
<td>1,772</td>
<td></td>
</tr>
</tbody>
</table>

Source: DEET, National Report on Australia's Higher Education, Table 3.7

Overview of Australian industry (update)
The Australian economy comprises of a broad range of industrial sectors, from agriculture, mining and manufacturing to transport, tourism, communication and business services. Although the primary industries (agriculture and minerals) remain strong, over the past two decades the economy has come to be dominated more by the manufacturing, wholesale, property/business industries and to a lesser extent, health and community services. This reflects a shift toward more knowledge intensive industrial activity.

Other service industries, such as retail trade, communication, and finance and insurance have been steadily gaining prominence, in line with current trends throughout the western world. While in terms of contribution to GDP, they are still far less significant than Australia’s ‘traditional’ industrial sectors, estimates suggest that this gap will continue to close over the next decade.

Contribution to national GDP from the goods-producing industries has remained relatively stable over the past three years. Over a ten year period however, there has been a relative decline. The two most significant contributions come from manufacturing, which in 1993-94 contributed 14.4% to GDP, and wholesale trade, which contributed 10.8% to GDP. Finance and insurance, and property and business services have also increased their contribution to GDP steadily through the 1990s. The mining sector, on the other hand, has experienced a continuing decline from the mid-1980s, when it contributed 6.6% to GDP, to 3.8% in 1993-94 (ABS 1996b: 355-6).

One indicator of the trend toward greater knowledge intensity is business expenditure on research and development. An indicator of knowledge-based collaboration is business expenditure on R&D invested in university collaboration. The level of expenditure on
R&D within the business sector in Australia has increased steadily from 1988-89, with a strong increase of 10% in 1994-95 to just under $3.5 billion or 0.74% of GDP. (ABS, 1996a). Over the decade to 1994-95, Australian business R&D almost doubled, as a proportion of GDP, and now comprises half of all Australian R&D investment. These investments are predominantly concentrated in the manufacturing sector. The majority of R&D expenditure was concentrated in motor vehicles, paper products and printing, and food and beverages.

(#UPDATE) Between 1981 and 1991, business sector funding for higher education research increased by 74%, indicating a considerable growth in industry–university research links. While a comparatively small proportion of university R&D funding came directly from Australian industry (5%) this amount has been steadily increasing (ABS - 1999). Table 2 illustrates the interconnection between government funded basic research in universities and industry funded experimental development. As the Australian economy moves more toward knowledge intensity this is reflected in closer alliances and collaboration between universities and industry.

**Table 2** Australia: R&D expenditure by sector of performance and type of activity, 1992-93 (update) for 1999

<table>
<thead>
<tr>
<th>Source of funds for academic R&amp;D</th>
<th>Type of Research</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pure Basic Research</td>
<td></td>
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<tr>
<td>Business sector</td>
<td></td>
<td></td>
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<tr>
<td>University sector</td>
<td></td>
<td></td>
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<tr>
<td>Other sector</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td></td>
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</tbody>
</table>

Source: ABS 1995, Catalogue No. 8112.0

Many cooperative mechanisms encourage three way (university–industry–government laboratory) collaborations. In important aspect of R&D carried out at universities is the training ground provided for future technicians and entrepreneurs in knowledge-based industries. Table 3 shows the current focus of research training in Australia by field of study.
Table 3  Total doctoral students in Australian universities by field of study, (data)

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</thead>
<tbody>
<tr>
<td>1994</td>
<td>1,166</td>
<td>235</td>
<td>2,207</td>
<td>5,537</td>
<td>1,504</td>
<td>2,218</td>
<td>4,594</td>
<td>742</td>
<td>262</td>
<td>207</td>
<td>20,666</td>
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<tr>
<td>1995</td>
<td>1,547</td>
<td>246</td>
<td>2,533</td>
<td>6,091</td>
<td>1,853</td>
<td>2,357</td>
<td>5,111</td>
<td>806</td>
<td>280</td>
<td>213</td>
<td>23,032</td>
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<td>1996</td>
<td>1,787</td>
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<td>2,687</td>
<td>6,445</td>
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<td>2,318</td>
<td>5,742</td>
<td>853</td>
<td>222</td>
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<td>1997</td>
<td>2,059</td>
<td>352</td>
<td>3,052</td>
<td>6,573</td>
<td>2,408</td>
<td>2,320</td>
<td>6,267</td>
<td>896</td>
<td>249</td>
<td>183</td>
<td>26,356</td>
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<tr>
<td>1998</td>
<td>2,265</td>
<td>403</td>
<td>3,367</td>
<td>6,603</td>
<td>2,581</td>
<td>2,370</td>
<td>6,565</td>
<td>843</td>
<td>277</td>
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<tr>
<td>1999</td>
<td>2,681</td>
<td>431</td>
<td>3,668</td>
<td>6,896</td>
<td>2,806</td>
<td>2,419</td>
<td>7,108</td>
<td>848</td>
<td>336</td>
<td>173</td>
<td>29,365</td>
</tr>
</tbody>
</table>

Source: DEEYA, ...1999

Policy initiatives to promote knowledge-based collaboration between industry and higher education
The Australian government has introduced a range of initiatives intended to stimulate closer collaboration in industrial research and human resource development for new technologies. The following section provides a brief summary of some of the key features.

A program of Key Centres for Teaching and Research was introduced to enhance the teaching and research output of colleges in the advanced education sector. In 1997 there were 15 Key Centres operating across 13 of the 36 Australian universities.

It is interesting to note that this program has provided a corner-stone for further developing cooperation with industry. For example, a 1992 review of the program noted that many linkages, such as contract and cooperative ventures that emerged from the program, would not otherwise have occurred. Further, the review found that in some cases centres had generated funds from industry up to seven times the value of the original government grant (Australian Research Council, 1992:12).

From the teaching perspective, it was observed that the KCTRs had been successful in more closely linking teaching programs to the needs of industry by bringing together different disciplinary strands into multi-disciplinary teaching programs that directly addressed the training needs of particular industries.

Benefits of the program from the university perspective included both the attraction of industry funding for specific training packages as well as the perceived ‘fine tuning’ of more general undergraduate and postgraduate teaching. This program illustrates in an interesting way the convergence between teaching, research and consulting activities and a more integrated approach to human resource development for knowledge intensive industries.
The ARC Collaborative Research Grants program was established in October 1991 to support high quality research of social and economic benefit to Australia and to encourage research collaboration between universities and industry. The program funds projects that extend from basic and strategic to applied research and development with funding being provided on a matching dollar-for-dollar basis with industry for periods of up to three years.

Overall the program tends to support research activities in the fields of applied science and technology and information and computer science, with a smaller proportion of the budget going to physical science, earth science and medical and health sciences. Because the scheme is project-focused it tends to support linkages between individual researchers in each sector and does not depend on the existence of a formalised research centre, or jointly managed commercial enterprise. However, one of the implications of the program is its capacity to generate longer term and sustainable cooperative mechanisms between industrial and academic institutions.

The Australian Post graduate Awards (Industry) program provides an industry-linked research funding program that directly links the research and teaching components of university activities with industry.

Table 4 shows the proportion of industry-based awards among all Australian Research Council funded postgraduate research awards by field of research. These data show the principal fields of research where this cooperative mechanism is most concentrated, emphasising concentrations of current industry based HRD research training.

Table 4  Australian Research Council Expenditure on Postgraduate Awards by Type of Award and Field of Research, 1994 (update# ?)
The three programs described above have more recently been integrated into one overall scheme known as Strategic Partnerships for Industry Research and Training (SPIRT). This approach reflects a deeper trend in Australia toward an integrated approach to teaching and research for technology based industrial development.

**Competitive Grants for R&D**, within the industry portfolio, brings together what were until recently five separate programs. Two of these were initially designed to overcome barriers to cooperation between universities and industry. These were the Generic Technology Grants Scheme (GTGS), and the National Teaching Company Scheme (NTCS).

The GTGS was set up to foster research collaboration. Each project requires a commercial partner, so research conducted under these grants is directly relevant to industrial problem-solving or innovative activities. They were initially provided across a wide range of industries considered to be important for Australia’s competitiveness. Originally three areas were identified: biotechnology, new materials technology and information technology. Communications technology and environmental technology were later added. Although the scheme has some similarities to the CRC scheme, discussed below, in the sense that the focus is to enhance research capacity and to link university research with industries, the difference lies in the scheme’s strategic direction of research into pre-identified areas. It is clear too, that Generic Technology Grants projects served as precursors to more structured institutional collaborative arrangements in many knowledge intensive areas such as photonics..

The NTCS projects seek to support the establishment of new linkages between companies and tertiary institutions through grants for the appointment of graduates over a two-year period, to work on a specific research and development project. The graduate, in turn, is provided with experience in industry and the institution has the opportunity to collaborate with industry on market-oriented projects. Recent reviews of the teaching companies scheme have found that while the scheme did not necessarily promote further R&D in industry it did promote further collaboration.

...it is quite possible that without the NTCS projects would have been undertaken in-house, rather than in collaboration with a research institution (BIE, 1991:60).

The **Cooperative Research Centres** Program was launched in May 1990 with the intent to fund up to 50 centres. The total government funding commitment was estimated to rise to $100 million per year by 1995 and attract matching funding from both the private sector, universities and government research institutions. Thirty-five centres were announced in the first and second rounds of applications, and there are now 62 functioning centres.
There are four important features that have emerged from the Australian CRC experience. Firstly, they have been built around existing, but less formal research links (Liyanage and Mitchell 1993). Second, they have become important structures for postgraduate research studies, and third, they have contributed to the development of ‘peripheral research alliances’ beyond the core members of the CRC. Finally, they have played a formative role in changing research cultures in both industry and academic research groups (DIST, 1995).

Future developments in technical and further education for knowledge-based industries

The need to pursue international competitiveness in industry has generated a strong push to expand vocational education and the skill levels of the labour force. A significant player in these changes has been the vocational education sector mainly delivered through the TAFE (Technical and Further Education) system – a large network of technical colleges and institutes in almost every substantial population centre. The boundary between the TAFE and university sector has become increasingly blurred, through the inclusion of four universities which incorporate a TAFE component in their structure within the Unified National System. In addition, there has been steady progress towards articulation of TAFE qualifications with university degree programs, and a significant level of TAFE-university collaboration in the development of new training programs for industry.

The forms of cooperation between universities and industry in education and training can be usefully divided into two categories – ‘traditional’ and ‘new’. The traditional relationship has a long history, and takes a number of forms. Australian universities have adopted one or more of these forms to an extent governed by the perceived objectives of the institution.

One of the forms of cooperation in the traditional mode is associated with the professions – medicine, law, engineering – where course content and delivery is to a significant extent set by the governing body of the profession, and there are monitoring and review procedures to ensure that professional standards are maintained.

Another is student placements in the workplace for practical experience. There has been substantial growth in cooperative (formerly ‘sandwich’) programs which provide for substantial work experience as a component of the course, in addition to the more common vacation work experience pattern. Other forms include the appointment of individuals from appropriate industry or professional bodies to course advisory committees, appointment of adjunct professors who are employed in industry, and provision of funds by companies for Chairs in targeted fields.

Each of these forms of collaboration has developed strongly but by-and-large they have remained ‘arms length’ relationships, with relatively little consequence for the culture, the traditions, the objectives and the practices, of either industry or the universities. They are essentially marginal to the mainstream business of the organisations, and hence can
be comfortably organised and managed without threat or change to established beliefs and procedures.

In contrast, the ‘new’ forms of cooperation are much more far-reaching, and represent a very substantial transformation, in many cases, in the missions of universities, the objectives and importance of education in company planning, and in the nature of the relationship between the two players. These ventures are rather more in the form of partnerships or strategic alliances, and shaped by the experience that has been gained in the effective management of such alliances. They involve a much higher level of joint ownership, with course design, delivery assessment and overall evaluation being the product of a shared initiative involving committed staff from both university and company.

An examination of a range of these ‘new’ forms of cooperation has enabled the common features of successful cooperative education programs to be identified. These can be summarised as:

• shared governance through a board or committee that involved all parties, including unions and professional bodies;
• a formal agreement clearly stating roles and responsibilities;
• commitment of development funds by the partners or through external seed funding;
• open communication;
• shared needs analysis of the workplace;
• shared curriculum development;
• shared delivery of the program using innovative methods suited to the needs of the workplace, reflecting the distinctive strengths of the partners and the organisational structure of the employer;
• administrative, academic, financial, technical, and human resource systems geared to flexible delivery and client service.\(^{11}\)

Of the total of 36 Australian public universities, 23 have reported at least one program which fits the guidelines of new cooperative education ventures. However there is a substantial level of concentration, with just five universities accounting for 50% of the programs, by number.\(^{12}\)

It is the newer universities, rather than the more traditional and long-established universities, which apparently are seeing the opportunity to establish a market presence for themselves in cooperative education. Their relative youth may also suggest that there are fewer entrenched attitudes and practices to overcome.

With regard to the *type of partner*, the following figures indicate that it is the private sector and government that dominate, to about an equal extent:

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\(^{11}\) See Turpin *et al.*, 1996, *op. cit.*

Private Company(ies) & 30 
Industry Associations & 11 
Government Agency & 19 
Government Department & 11 
(incl Public Service Commission) &  
Professional Association & 12 
Trade Union & 2 

In total, 54% of programs are with industry, either directly with companies, or via industry associations. Government, in various guises, is involved in 39% of the cooperative programs. The other major category of partner is professional associations.

With regard to the type of economic activity of the partner, it is the producer services, in particular financial services, accounting, consulting and management that are the largest category, involved in 32% of programs.

The pattern by economic activity is concentrated very strongly towards the service industries. All told, three-quarters of partners are in this sector which is not only the largest, but the fastest growing.

With regard to the type of course, the majority are specialised non-award courses for industry partners (34%), or subjects which could also contribute towards accredited courses (18%). These were followed by courses leading to a Graduate Certificate (17%), Diploma or Associate Diploma (14%), or a professional qualification (9%). Significantly, only 8% of programs were designed to lead to an undergraduate or postgraduate degree.

With regard to the target audience of the program, for most companies and government departments and agencies it was their staff, for industry associations it was the staff of their member organisations, and for professional associations it was their members.

Recent initiatives reflect an apparently new process of commercial organisations inviting universities to tender to deliver their training needs, or their programs. For the latter, this model has been established through the various Public Service Commissions, which have invited tenders for the design and delivery of specified training programs. However the model has recently been extended to the private sector, with the Australian Institute of Company Directors calling for expressions of interest from universities in:

- articulating their Company Director course to graduate certificate, graduate diploma and higher degrees;
- delivering the Company Director and related courses under contract from their State Divisions;
- working with their National Education Committee to develop programs and the production of course materials.

In something of a landmark case in cooperative education, Elders Ltd, a large provider of services to the rural industries (woolbroking, livestock, merchandising, real estate,
finance and insurance) with over 1500 employees, has taken the initiative in calling for
tenders from universities to become a partner in the delivery of enterprise based
educational programs. The major areas of competency development identified planning
by Elders are: policy development, information management, leadership, communication,
selling and marketing, customer service, quality improvement processes, personal
effectiveness, systems thinking, problem solving skills, the business environment, and
global business trends. The requirements of the university provider (see box) can be read
as a definitive checklist of the ‘new’ strongly customer-driven cooperative education. We
suggest that perhaps this may represent a template for future industry–university
cooperative ventures in education and training.\textsuperscript{13}

\textsuperscript{13} \textit{ibid}
A template for university and industry collaboration in human resource development for knowledge-based economies

*With regard to delivery the training should:*
  * be oriented to the needs of students at multi-remote sites in Australia and overseas;*
  * use modern educational technology;*
  * not require face to face contact;*
  * be interactive.*

*With regard to content and structure, the university must:*
  * be able to deliver content that draws from contemporary practice in the commercial arena;*
  * recognise the importance of imparting both operational and strategic skills;*
  * recognise prior learning in award requirements;*
  * be able to structure study programs to comply with the requirements of a hierarchy of undergraduate awards;*
  * be able to structure subjects into a modular format;*
  * be able to provide pathways for generalist and specialist interest; and*
  * relate to day to day operations, expectations and management.*

*Learning methodologies must:*
  * reflect adult learning principles;*
  * facilitate learning through action learning and research;*
  * orient assessment toward work based projects.*

*With regard to administration, the university must have systems and procedures which are able to:*
  * accept continuous enrolments;*
  * allow students multiple entry and exit points;*
  * accept single subject enrolments;*
  * accept award and non-award enrolments;*
  * flexibly respond to client needs.*
4. An Australian Case-Study: TELSTRA

_Human Resource Development for Telecommunications_

Telstra’s origins date back to 1901, when the Postmaster-General’s Department (PMG) was established to manage all domestic telephone, telegraph and postal services. The Overseas Telecommunications Commission (OTC) was established in 1946 to manage Australia’s international telecommunications.

The Australian Telecommunications Commission, trading as Telecom Australia, was created as a separate entity in July 1975 following the break-up of the PMG. OTC and Telecom Australia became the Australian and Overseas Telecommunications Corporation (AOTC) following a merger in February 1992.

Telstra Corporation Limited (ACN 051 775 556) became the legal corporate name of the merged entity in April 1993.

_Involvement in the Commonwealth Government’s Cooperative Research Centre (CRC) Program_

Telstra has selectively chosen to be part of a limited number of the Commonwealth Government’s Cooperative Research Centres. Telstra’s involvement is mainly through the sharing of research information between TRL and the participants. This ‘in-kind’ contribution to a CRC is, in some cases, augmented by cash inputs to cover the conduct of specific R&D under contract to one or more of the CRC participants. TRL is currently involved with the following CRCs:

**Australian Photonics Cooperative Research Centre – Universities of Melbourne and Sydney**

TRL is a participant in the APCRC through R&D contracts with both Melbourne and Sydney Universities and by activities undertaken within its own research program which are shared with the CRC participants. The work with Melbourne University goes back to July 1989 for pioneering research in the important areas of photonics, the development of switching techniques based on optical instead of electrical methods. TRL is also actively supporting research in the Optical Fibre Technology Centre of Sydney University and is specifically contributing to the development of in-fibre grating technology.

**Distributed System Technology Cooperative Research Centre – University of Queensland**

This CRC develops the technologies to build distributed information systems providing sophisticated information services to geographically dispersed users over powerful networks. TRL’s contribution to the CRC is primarily through the funding of the Telstra Centre of Expertise in Distributed Information Systems which was established at the University of Queensland in 1988 and is now an important part of the CRC. The Centre facilitates research into the architectures, management and standards development for the networking of information held on different computers. This work is of particular importance in network management, intelligent networks and charging and billing.
functions as well as in a range of service offerings such as directories and other network control systems. TRL is planning to alter the balance between in-kind support and direct funding for this CRC to improve the technology transfer between the organisations.

**Research Data Network Cooperative Research Centre – Monash University**
The Research Data Network (RDN) CRC conducts research and education programs in areas relating to communications network technologies, applications and services. It also supports network infrastructure development, including the upgrade of the Australian Academic and Research Network (AARNet) which is now owned and operated by Telstra. Telstra’s involvement includes the provision of access to broadband facilities such as the Experimental Broadband Network at the various CRC participants’ sites. TRL supports an R&D program which is being conducted collaboratively with the Monash University node of the CRC.

**Centres of expertise**
Telstra Centres of Expertise have been established in selected tertiary institutions to augment Telstra’s needs for research in important telecommunications topics. The Centres provide important additional research skills which are an adjunct to Telstra’s longer-term research topics. They also foster a pool of expertise at both graduate and postgraduate levels to enhance future recruitment for Telstra and the telecommunications industry.

**Educational fellowships**
Telstra, through its Research Laboratories, assists a select number of outstanding undergraduate and postgraduate students who are undertaking studies in telecommunications topics at Australian tertiary educational institutions.

The fellowship scheme for undergraduate students is for those who are completing the final year of a course of tertiary study leading to a Bachelor Degree in engineering or science. While the fellowship scheme does not commit the holder to join Telstra on graduation, it does require them to work at TRL during their vacation period and it is hoped that they will favourably consider selecting Telstra for their future professional career.

An additional scheme for academic staff of Australian tertiary educational institutions provides a short-term fellowship to enable them to undertake specific research work at TRL during their sabbatical leave or vacation. This is to encourage academic staff to include telecommunications topics in their curricula and thus benefit the future Australian telecommunications sector.

**Tertiary education course advisory bodies**
Senior staff of Telstra are active members of a range of advisory committees of education establishments. Their advice to these committees ensures that the teaching programs offered by tertiary institutions continue to have relevance to the needs of Telstra and the telecommunications industry.
Other education and training interaction

Linkages between Telstra and the universities in the fields of education and training are managed through the Education and Industry Training Strategy Unit, Telstra Learning. As part of the development of their people, Telstra, through Telstra Learning, is establishing a learning culture throughout the Corporation. Employees are encouraged to use their full capacities to learn continuously, to initiate, to question, to be creative and to express their ideas freely. The new learning culture also encourages managers to support their staff better, to treat them as their customers, and develop their own skills in recognising problems. Telstra has identified specific education and training needs and called for tenders from universities to supply the required services. This mechanism has also been used as a process of accreditation of in-company programs.

In general, Telstra staff are involved in both design and delivery, and in some cases the link with the university is seen as a temporary relationship which will be supplanted by full in-house delivery.

Specific programs currently in operation are:

- Telstra Team Leader Development Program with Deakin University. This is designed for front line managers to develop key management skills. It is managed through a joint Steering Committee of Telstra and Deakin Australia.
- Certificate of Management, Graduate Certificate of Management and MBA with Southern Cross University.
- Diploma of Adult Education with the University of Technology, Sydney. This is designed to develop professional skills of Telstra staff involved in training.
- Finance Training Program with the Open Learning Agency.

As one of Australia’s largest companies, Telstra is moving to become a far more demanding customer of the university education system. The previous model of recruiting generally educated electrical/electronic engineers is no longer considered adequate. Telstra is seeking to influence government policy and the policies of individual universities, to deliver to industry, graduates who have the necessary skills to enter the telecommunications industry and make an immediate contribution. Greater flexibility is expected from universities, particularly in articulation of company in-house technical training into university degree programs.

5. Summary and Discussion

The Australian case-study on human resource development for knowledge-based industries reflects the same trends that can be observed in North America. They all illustrate a far more complex set of interactions taking place between universities and industry than is generally acknowledged. It is not simply a set of collaborative partnerships that are involved but the creation of knowledge systems based on organisational collaboration. Such collaboration involves many ‘players’. Universities
and industrial firms are only some of the institutional components in these systems. Further, their roles appear to be undergoing considerable transformation.

Comparing the Australian case with North American experiences allows a number of common features to be observed. First, there is a formative role played by regional governments. In almost all cases, some form of agency or authority has been instrumental in promoting partnerships. In some cases, they are directly involved in the partnerships themselves. But perhaps more significant, is their role in establishing and analysing enduring structures. This is a very local dimension to collaboration.

Second, within these partnerships there is increasing potential for ambiguity about the role of the partners. Universities and industrial firms are both users in ‘knowledge networks’: both provide knowledge, both deliver financial resources, both are involved in curriculum development and delivery and both are involved in research. Some collaborative mechanisms have been driven more by university partners, others have been driven more by industry. Yet others have emerged as a direct result of intervention by an intermediary agency.

Third, collaborative partnerships between universities and industry are far more complex than simply two or three way organisational partnerships. Collaboration is occurring through the development of ‘knowledge-systems’. While they may have a national base these systems are also international and increasingly, transnational. There are many constituent parts to these systems. The North Carolina Research Triangle provides a particularly dynamic version of such a system. But it is the structure of the collaborative process that is important not the size or age.

Within more structured collaborative systems, such as those described above, there is a clear recognition of the need to understand the consequent organisational and management issues and problems. In short, human resource development for knowledge-based economies is viewed as much a management issue as it is a technological issue.

In Australia we often tend to undervalue and under-utilise the capacity of universities to solve complex organisational problems. In the emerging knowledge systems discussed above, the commitment to understanding organisational processes must be an explicit and high priority.

Human resource development for knowledge intensive industries in Australia is strongly built around collaborative partnerships between universities and industry. Australian universities, like their counterparts elsewhere, are becoming more international in focus and are involved in activities quite different from their activities earlier this century. In doing so they are moving beyond traditional knowledge diffusion processes such as undergraduate and graduate teaching and presenting research publications. They have adopted a far more proactive role.

In education and training, industry now calls for the delivery of more ‘enterprise-based’ university training which involves a much higher level of joint ownership of course
design, delivery, student assessment, and overall evaluation. Yet there are organisational and institutional implications arising from this. Will such a trend serve to actually curtail the diffusion of knowledge? Is there an emerging contradiction between the production and diffusion of public knowledge in universities and university/industry partnerships designed for increasing private sector competitiveness? These are critical questions for the future.