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Vocational education and training and innovation

Research readings

Edited by
Susan Dawe

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Clifford Trood has taught communications and engineering at TAFE NSW for several years, and is currently their Head Teacher of Engineering. He has pursued an interest in innovation and knowledge diffusion, which led to research at the Department of Education and Training's TAFE NSW Industry Partnership Centre at the Australian Technology Park in 2001. This work investigated the relationships between vocational education and training, and the national innovation system. Clifford has written and presented on these topics at a range of industry and education forums.

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Overview

Hugh Guthrie and Susan Dawe

This book of readings was commissioned to enable a better understanding of the past, present and future role of the Australian vocational education and training (VET) sector in business innovation. This collection considers what the innovation process in business means for Australian workers and identifies the contributions of the VET system. International comparisons offer insights into those elements missing or under-emphasised in the current Australian innovation system. Finally, strategies to enable the VET sector to engage with business innovation are illustrated through examples. This overview introduces the book and discusses important findings and common messages from its chapters.

What is innovation?

THE READINGS IN this book have been chosen to highlight the innovation process in industry and how vocational education and training can, and is, contributing to it. A number of different perspectives are presented. First of all, however, let us consider the concept of innovation.

It is generally agreed that innovation involves doing something new or doing existing things in a new way, although, in his chapter, Kearney argues that it is only when 'doing something new or differently' is commercialised or applied in the community that it becomes an 'innovation'. Moreover, his definition of innovation states that, to be an innovation, it must *add value* to a business operation or be useful to the community in which it is applied.

Innovations cover a wide spectrum, from high-profile scientific discoveries to low-profile changes in existing processes or practices. Pickersgill, offering a historical overview, points out that the Australian skilled workforce has been involved in adaptive innovation of European and American products and processes to Australian conditions since colonial days. Curtain, in his chapter, also refers to 'organisational innovation' (changes in work practices) and 'presentation innovation' (changes in design and marketing) in which vocational education and training has played a role.

Australian Government policy to date has focused on the high-profile innovations as represented by the co-operative research centres. While

vocational education and training should have a role to play in these, to date the contribution of this sector has been relatively insignificant (see chapter by Whittingham, Ferrier & Trood). However, in a recent publication for the Committee for Economic Development in Australia, Smith (2004) noted that we need to move from this 'scientific discovery' notion of innovation to one which also embraces continuous learning. Innovation in the major industries on which Australia's economy rests occurs in this way. These industries are indirect users of research and development, and are innovative largely as a result of re-combining or adapting technology or knowledge. This innovation is driven, as Bennett, Brunker and Hodges suggest, by such drivers as the search for competitive advantage—new and untapped market places, updated technologies or needed organisational change. Often, as we shall see later, these innovations involve developing useful relationships and partnerships with other organisations.

Innovation, especially process and incremental innovation, depends on a skilled workforce and this will be doubly so in the future. As Curtain so eloquently reminds us, it is enterprises, not governments, which are at the heart of the innovation process. Enterprises take new ideas, turn them into a product or service and then market the result. In turn, they need the right people with the right skills and knowledge to help them do this. People are the innovators.

VET's role in business innovation in Australia

Pickersgill provides an historical perspective to innovation in Australia, and the role played by the VET sector. He argues that product and process innovation in Australia since colonial times demonstrates the integration of Australian industry with the rest of the world.

The colonial settlers studied information about the latest scientific and technological developments from Europe and America. Skilled migrants arrived with the new equipment imported by the settlers. However, the new equipment and ideas needed to be adapted to the local conditions. Thus, innovation in Australian industry generally occurred through the extension and modification of existing technologies to new purposes. Technical training was developed to support the growing workforce as there was relatively limited access to both secondary and university studies in the nineteenth and early twentieth centuries. Since Australia had relatively little public research and development capacity, business innovation typically relied on VET-trained workers rather than research and development departments.

According to Pickersgill, the lesson that history can provide is that, if technical and other forms of education and training are to be successful, they need to be based on practical developments in current workplaces.

International comparisons offer insights into the elements which are missing or under-emphasised in the current Australian innovation system. Curtain uses

Finland and Singapore as examples of the important role of human capital in economies with strong track records in innovation.

While Australia has improved its innovative capacity, it has not performed as well as its international competitors in the research and development and scientific discovery end. While Australia is ranked in the top six Organisation for Economic Co-operation and Development (OECD) countries for government expenditure on research and development, business investment in innovation is far below comparable OECD countries. This results in a lack of capacity for commercialising innovative ideas which are generated in Australia—hence, the Australian Government's focus on innovation.

From experiences in the United Kingdom and United States, Curtain suggests that there is a danger in focusing *only* on those innovations concerned with high technology as contributors to economic growth. As he points out, the application of new knowledge and processes to 'low tech' industries (such as vegetable production and marketing) can have a marked effect on the success of an enterprise. These 'low tech' industries are those which are traditional VET sector markets.

To enhance the links between the VET sector and business innovation in Australia, Curtain makes two suggestions, namely:

- Access to government research and development funding, focusing on processes and development rather than pure research, would bring the VET sector in Australia closer to business innovation.
- Government research and development funding to the VET sector could be solely focused on small and medium-sized enterprises.

According to Toner (2004), in other countries, such as Finland, Germany and the United States, public vocational colleges are an important part of national innovation policies. The colleges run innovation diffusion programs to encourage the uptake of technologies and raise the average level of firm productivity—especially in small-to-medium-sized firms. These programs include a broad range of consultancy, technology demonstration and applied research and development functions, which are separate from traditional classroom teaching.

In their chapter, Toner, Marceau, Hall and Considine identify innovative industries and firms in Australia, and examine the role of technical occupations in these firms. Those factors identified as strongly stimulating innovation were also identified as strongly stimulating training. Such factors include investment in new equipment, strong competition based on product differentiation, quality, reducing product cycles, timeliness of supply and integrating product services. Also important is consultation with workers, suppliers and customers for product and process improvements, and well-functioning linkages with external research and educational institutions.

According to these authors, innovation-intensive firms especially value the practical orientation of VET training. They seek flexibility in training arrangements, such as on-the-job delivery and customised training, to link off-the-job training directly to specific on-the-job work practices. Close collaboration with industry partners will enable VET providers to ensure the appropriate balance of practical and theoretical skills.

Kearney examines the evolving workplace. He suggests that innovative and successful companies align their organisational culture, systems, processes and resources so that they are focused on meeting corporate goals. Openness, trust and diversity in the workforce are essential for a culture of innovation, he says. If the VET sector is to play a role in the innovation process, then it must provide a learning environment which also reinforces and develops these qualities.

According to Kearney, innovative companies also recognise the value that different perspectives can bring to the creation of new products and services, the solving of problems and the generation of new opportunities. Such companies invest in their human capital, empower their people and create free spaces for learning to occur. Innovative businesses strive to attract new skills to the organisation, or make better use of the skills they already have. Individual creativity and innovation skills are important components of this diverse workforce, and they need to be addressed by VET providers.

Bennett, Brunker and Hodges discuss some key human capital challenges to be faced in ensuring that the Australian economy maximises opportunities for innovation and economic growth. They believe the key drivers to be competition, intellectual property rights and a culture of innovation supported by a strong knowledge base. These will help generate new ideas and realise effective commercialisation.

These writers believe that a culture of innovation is dependent on fostering problem-solving, creativity, entrepreneurship, initiative and drive. They also note that many small enterprises are owned and operated by people who have developed their human capital outside the higher education system. Many of these operators have developed their skills and knowledge within the VET sector.

Misko, Saunders and Woods describe the training needs of companies which are developing new ideas and applying 'innovative technologies'. They note that, in the early stages, innovative companies tend to employ staff with the highly specialised skills and knowledge needed. As the companies shift from experimentation and development to production and marketing, their workforce grows and their training needs become more conventional.

According to these authors, any training needed by companies in the early stages of innovation is for relatively small numbers of employees and often ahead of the knowledge or skills in existing training courses. However, VET providers are well placed to build on current training courses and customise

training for these companies. During this process VET staff also gain access to the latest technologies and procedures—and companies gain access to VET training expertise in their development phase. Thus collaborative approaches between these companies and training providers can be mutually beneficial.

Whittingham, Ferrier and Trood note that the VET sector is not as involved as it should be in the national innovation system as represented by Australia's co-operative research centres. Many of these centres are working towards improving products and processes for existing industries but there is no systematic process to ensure that new knowledge and skills created in the centres flow to the VET sector.

They conclude that, overall, about 60% of co-operative research centres' programs were conducted in areas where there was an existing VET program or course. They believe that the co-operative research centres need to recognise the VET sector as an end-user of their research outcomes, and a useful contributor to design and applications of new tools, systems and processes. In addition, the VET sector is a primary stakeholder in the transfer process for the successful adoption and implementation of their outputs in industries and enterprises.

Strong connections were defined by Whittingham and colleagues as 'a committed relationship generally formalised in an agreement or strong personal long-term commitments'. Of more than 60 centres in existence, strong connections with the VET sector occur in about ten centres, notably in the fields of agricultural and rural-based manufacturing, environment, and manufacturing technology. Where the links are strongest, benefits flow both ways. Centres gain from the skills and experience of VET personnel and their industry links, while the VET sector benefits through new opportunities for professional development of teaching staff and fee-for-service provision of training. Establishing long-term connections with the centres will help ensure that the currency of VET programs is maintained, the training needs of emerging industries, enterprises and individuals are met, and the knowledge and skills of VET staff remain close to the forefront of practice.

Loble and Williams discuss the need to re-position skills policy within economic and labour market policy. Critical to this is the development of a new skills policy framework—'skillecosystems'. Skillecosystems are independent clusters of skills within regions or industries shaped by the nature and networks of firms, products and processes, markets and market regulations, key institutions, policies and regulatory authorities.

According to these authors, simply increasing the supply side—the quality and quantity of skills regardless of what those skills are—will not in itself create more or better employment or lead to economic growth. The challenge of reconciling supply with demand is broader and requires increasing the demand side.

They note that innovation is not an entirely random process and can be promoted by specific policies, especially skillecosystems. One example cited in

their chapter is the Water Innovation Network consortium, which includes United Water and Torrens Valley Institute of TAFE in South Australia. A second demonstration project is technology-transfer through Swinburne University of Technology, TAFE Division in Victoria. In conjunction with the Microtechnology Co-operative Research Centre and its prototyping offshoot, MiniFab, Swinburne is leading a project to promote knowledge and application of microtechnology across small-to-medium-sized manufacturing enterprises in Victoria.

In summary, it seems that the VET sector can have at least five roles in the innovation process:

- monitoring innovations and assessing their impact and relevance for VET programs
- developing appropriate relationships with suppliers of new equipment and technology and customising programs to meet the specific training needs of their customers
- assisting, through skills development, the successful transfer and adoption of new innovations in industries, companies etc.
- fostering and building innovation skills, especially problem-solving, creativity, entrepreneurship, initiative and drive in its students
- working collaboratively with industry or research and development organisations, particularly focusing on processes and development rather than pure research, and supporting small and medium-sized enterprises.

As described in the next chapters of the book, linkages and partnerships with businesses should be carefully assessed for their relevance to core VET business. They should only be taken up if adequate benefits can be identified.

VET and business: Improving linkages and partnerships

Callan identifies nine characteristics of innovative enterprises. These enterprises create learning cultures, make innovation a core capability, identify their innovators and reward people for bringing forward innovative ideas. They also use partnerships to bring in new knowledge which drives further innovation, have leaders who are risk-tolerant, develop teams and cross-functional teams, create communities of practice which meet regularly to discuss common interests, and provide places to be innovative.

After examining VET organisations against these nine characteristics, Callan contends that the development of innovation in training providers can be described at best as 'uneven'. Some exceptional individuals and teams within VET institutions are leading the way in developing more responsive and flexible

training for industry. While no single VET institution is regarded by Callan as an 'innovative organisation' that has innovation as a core capability, many have begun the journey. He argues that innovation in the strategic planning process would strengthen this capability across the whole organisation.

Callan also notes that successful innovation requires an ability to harvest ideas and expertise from a wide array of sources. His research describes the use of partnerships to promote innovation and empower VET staff at all levels to develop new and different ways of meeting the training needs of employers. In Callan's view, the best way to do this is through more formal partnerships, which find ways for organisations to share their skills and knowledge. Partnerships are more likely to mean that innovative projects are allowed to continue, despite cut-backs or changed priorities. This is because of the vested interest of all parties in their continuation.

Earlier chapters in this book also note the benefits to be gained from VET partnerships with industry. This includes competing organisations which may apply their skills and resources in innovative ventures. In their chapter, Lindhjem and Royle note the importance of this form of collaboration, which they call 'co-optition', whereby one training provider works with other public or private training providers to share knowledge, skills or resources in a joint venture.

The remaining chapters in this book focus on examples of the strategies which VET providers use to engage with business innovation. The authors focus on strategic planning, cost–benefit analysis, change management, curriculum initiatives, and engaging with new technology.

Strategic planning

Chennell describes the strategy used by Central TAFE, the largest technical and further education (TAFE) college in Western Australia, to become an innovative participant in the knowledge economy and provide linkages to clusters of industry players. These included manufacturers, suppliers, educational and research institutions and government agencies. Their conceptual framework, called 'Central Innovation', started them on their innovation journey and uses an industry cluster approach.

By identifying specific target areas of strength, and focusing resources in these areas, the college is able to build expertise, and leverage funds and industry support. In late 1999, the Western Australia Department of Training, in conjunction with the State Training Board, established the Science and Technology Innovation Fund. This fund provided Central TAFE with the opportunity to launch their applied research and development strategy and undertake research in a range of selected fields. This enabled acquisition of cutting-edge equipment and allowed students to be actively engaged in the research which, in turn, enhanced skills acquisition and student satisfaction.

Assessing the potential risks, costs and benefits

Lindhjem and Royle describe the importance of forming collaborative links or partnerships. They note the risk associated with entering new markets, and believe that this risk may be reduced by making careful choices about which emerging industries and training providers to work with.

The Opportunity Analysis Model is one tool which assists strategists to assess the opportunities available for work within emerging industries. The model facilitates consideration of the opportunities, risks, costs and benefits associated with participation in such ventures.

Change management and organisational renewal

Kangan Batman TAFE used the establishment of Victoria's new Automotive Centre of Excellence as the catalyst to build innovative capability. Browne, O'Sullivan and Julian describe the process of setting up a trial for the systematic development of innovative practice in the institute. This approach built on earlier research undertaken by Ratio Pty Ltd and presented in the publication *Innovation ideas that work* (ANTA 2002).

Kangan Batman TAFE began building the organisation's innovation capacity by developing innovation skills of staff who were selected from across the organisation (described as a vertical or diagonal cross-organisational staff team). This staff team then applied these skills to a work-based project. To support the resulting change in organisational culture, the staff also developed the leadership skills and organisational systems required. This is referred to as the 'inside-out approach', in contrast to the more usual 'outside-in approach'.

Three factors—time, training in innovation skills, and goals—were identified as critical to successful outcomes in building an innovative culture in the automotive group at Kangan Batman TAFE.

Curriculum initiatives

Down, in her chapter, describes the Applied Technology Framework, a curriculum initiative being trialled by the plumbing, waste management and precision manufacturing industries in conjunction with facilitators from the RMIT University. University staff assist workers to develop the skills of reflecting on their work practices and assessing what they have learnt.

Down also discusses the Applied Technology Framework as a mechanism for extending national training packages. This framework concentrates on the recognition of current skills and knowledge, and the requirement for workers to continue learning in the future. This includes development and delivery of flexible applied technology programs with effective articulation pathways and multiple entry and exit points. Opportunities for cross-sectoral skill development and relatively short intensive programs are also features of the framework.

Engaging with new technology

The last chapter provides an example of how industry is using the education sector to conduct research and development. Paez, Wilkes and Gurgone describe how staff and students at Central TAFE in Western Australia are engaging with an innovative application of speech recognition technology. This initiative is part of the Liberated Learning Project, which involves an international consortium comprising foundation partners, IBM Research in New York, the Alexander Graham Bell Institute of the University of Cape Breton in Nova Scotia, St Mary's University in Halifax, Canada, and other universities and colleges.

In Australia, the University of the Sunshine Coast and Central TAFE staff are pioneering and expanding the use of speech recognition technology to assist students with special needs, such as those with disabilities and those from non-English speaking backgrounds, in tertiary education lecturing and instructional settings. In Liberated Learning classrooms, lectures are transcribed in real time using automated speech recognition technology and projected to the class, enabling students to 'see' the lecture. Students at Central TAFE now have access to a range of multimedia material. They may access video, audio, software-generated text, and PowerPoint presentations, either individually or in any combination, depending on their learning preferences.

Key messages

Innovations may range from high-profile scientific discoveries to low-profile changes in processes or practices. The two common elements are that they are *doing* something new or differently which *adds value* to a business operation, or is useful to the community in which it is applied.

To date, Australian Government policy has focused on innovation based on scientific discovery and research and development. Although publicly funded research and development in Australia compares well internationally, local business investment in this type of innovation is comparatively low. This results in a lack of capacity to enable commercialisation of innovative ideas.

Australian Government policy needs to move from this 'scientific discovery' notion of innovation to one which sees it as a continuous learning process. This is the way innovation occurs in the major industries on which Australia's economy rests. These industries are indirect users of research and development, and innovation is largely based on re-combining or adapting knowledge. It is in this area that the VET sector has played, and will continue to play, an important role. There is also a role for vocational education and training in diffusion of technology throughout the workforce, a role which has not been fully tapped to date.

Work practices and workforce skills are critical to the innovation process. VET programs increasingly will need to develop an individual's capacity to think and act creatively with confidence.

VET providers need to work closely with industry, especially small and medium-sized enterprises, to introduce or implement innovation. This means government funding has to be available to VET providers to support such partnership development and programs; funding for teaching alone is not sufficient.

VET providers have an important role to play in providing training for innovative enterprises, but this may require working more effectively across disciplines and developing more personalised arrangements for delivery. VET providers need to identify where their strengths lie and build industry partnerships in these areas. Close collaboration with industry partners will enable VET providers to ensure the appropriate balance of practical and theoretical skills.

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The engagement of vocational education and training and innovation in Australia

Some historical perspectives

Richard Pickersgill
Charles Sturt University (Wagga Wagga Campus)

The significance of the state's role in developing colonial and post-Federation Australia is undisputed. As a 'settler society', its development into an industrial society followed some unique paths. The relatively small average size of (most) private firms combined with large public enterprises encouraged the development of skilled *occupational* labour markets where workers move between firms, rather than the *internal* labour markets whereby recruitment and career progression are conducted inside an organisation or enterprise. Internal labour markets are more characteristic of North American and Japanese firms. A reliance on foreign investment to expand production (accelerated after the Second World War) has been a primary means of technology transfer. Although there are important areas of basic science where Australia has made significant contributions, historical circumstances have emphasised process innovation, rather than *radical innovation* in Australian industry.

Although 'VET' is a recent acronym, 'technical education' has had an important role in Australia from the colonial period to the present. Free and secular primary education was established from the 1870s, but public high schools were a twentieth-century development. However, an extensive network of publicly funded schools of mines and industry, colleges of agriculture and technical institutes established prior to Federation continued to expand. Technical education in different states, notably New South Wales and Victoria, developed different institutional characteristics. However, all systems emphasised instruction in *broad occupationally defined skills*, rather than narrow job-specific skills. This reflected the specific nature of Australian industrial and agricultural development. Historically, Australian industry has emphasised incremental and process innovation, rather than radical technological breakthrough which depends on a skilled workforce educated through vocational education and training (VET) institutions.

Introduction

THE ADOPTION OF the acronym 'VET' in Australia in the context of a national vocational education system is quite recent. Under the Australian Constitution, the responsibility for education (including technical education) is a state responsibility. Although the Commonwealth had progressively become involved through specific purpose grants following the Kangan report (Australian Committee on Technical and Further Education 1974) in the mid-1970s, ultimate responsibility for vocational education and training remained with state systems. Following the establishment of the Australian National Training Authority (ANTA) in 1993, the current national VET system incorporates a range of financial and administrative features which reflect Commonwealth rather than state-specific priorities. These include the progressive adoption of a national curriculum and credentialling system, substantial federal direction and funding, and a political decision to shift the training system from an administrative model to one purportedly incorporating, and responsive to 'market' or 'demand side' forces. The new integrated national system is based on *agreement* between federal and state governments, *not constitutional authority*.

Superficially, the establishment in the 1990s of a national system may be seen as a radical break with previous state-based systems. From an historical perspective however, the differences are less significant than the continuities. National core curricula in many of the trades and other occupations were also an outcome of federal special purpose funding following the Kangan report (Australian Committee on Technical and Further Education 1974). Occupational structures and the influence of professional associations (for example, Lloyd 1968, 1984) had, in any case, functioned to ensure that core components of syllabuses were similar amongst the states, whether or not these were directly recognised as 'national' by individual state systems, or state-based accreditation or licensing authorities. A 'fitter was a fitter' irrespective of the state in which off-the-job training occurred. Occupational status was recognised by the labour market, and supported by industrial award classifications. The recent direct Commonwealth influence and funding for vocational education and training may be interpreted as an extension of other earlier post-war Commonwealth assumption of responsibility in tertiary and school education. However, this involvement continues to reflect the high level of public rather than private investment in education and training, which has been a feature in Australia since the provision of free secular primary education in the 1870s.

A sketch of developments across 200 years inevitably must rely on secondary sources. Unfortunately, readers in search of general history of technical and vocational education are, with the exception of Murray-Smith (1987), not particularly well served. That technical education, particularly its relation to

industrial development, has not been subject to more detailed historical scrutiny by educationalists is somewhat surprising.[1]

At the time of Federation, there were only three state high schools in Australia, all in New South Wales, although that same state had over 30 technical colleges serving both youth and older workers, and from the 1870s, all colonies had introduced a range of technical institutes, schools of mines and industry, agricultural colleges, technological museums and universities with chairs and departments in the natural and applied sciences. Even with the growth of high school systems in the twentieth century, most students still left at intermediate rather than matriculation level. High retention rates are a late twentieth-century phenomenon. The 'tech', not high schools or universities was the main formal route to a skilled occupation.

A national system of innovation?

The significance of 'innovation' as a key to national economic development has been most recently raised in the federal government's innovation action plan *Backing Australia's ability* (Commonwealth of Australia 2001). Innovation is seen as playing a crucial role in what has been termed the 'new economy', 'knowledge economy', 'knowledge-based economy' or 'learning economy' (for example, OECD 1992, 1999; Reich 1991; European Commission 1995; Marceau & Manley 2001). It is argued that 'knowledge will be the new international currency and our success in creating and using that currency will determine our future economic and social well-being' (Veenker 2001, p.2).

As Porter (1990, pp.20–1) notes, the key issue is to explain the role of the nation in innovation, and why some nations provide an environment more conducive to innovation than others. An unstated assumption in popular literature and current Australian policy statements is that 'innovation' is primarily equated with radical scientific and technological breakthroughs (Pickersgill & Walsh 2003). Yet in practice, much innovation is *process*-oriented, mundane and incremental in character. This latter form, as Todd (1995) has noted, has been typical of Australian industry. It suggests that Australian innovation policies could profitably take account of this less spectacular aspect of the innovation process.

Two general features have been significant to the development of an Australian system. The first has been the relatively small size of the local labour,

[1] Goozee (2001) has written a post-Kangan history of TAFE, and there are general histories of education or specialist histories which include general references to technical education such as Barcan (1980) and Austin and Selleck (1975). Crane and Walker (1957) and Selleck (1982) are important biographical studies of influential educationists Peter Board (New South Wales) and Frank Tate (Victoria) while celebratory Centenary histories include the Victorian Department of Education (1973), Murray-Smith and Dare (1987) on the Royal Melbourne Institute of Technology, Neil (1991) on Sydney Technical College and Cobb (2000) on the New South Wales system to 1949.

product and capital markets. Notwithstanding proportionally high concentrations in particular industry areas which developed in the late colonial and post-Federation periods (see Butlin, Barnard & Pincus 1982; Linge 1979), the small size of domestic markets has tended to encourage production based on 'jobbing' or short production runs. The mining industry from the 1870s, the steel industry in the 1920s and the post-war expansion of the petrol and chemical industries have, it is true, been based on continuous production. However, even mass production industries, such as motor vehicle manufacturing, are small by world standards, and others significant even 25 years ago, such as textile, clothing and footwear and whitegoods, have now virtually disappeared.

With some important exceptions, such as the former Broken Hill Proprietary Company and large public business enterprises, the majority of Australian firms have been small and have relied mainly on external sources, either immigration or the public training system, for formally developed occupational skills. State involvement in industrial and skill development under what Butlin termed 'colonial socialism' continued, albeit in gradually diminishing form, throughout the twentieth century (Butlin 1962; Butlin, Barnard & Pincus 1982). The role of the state in raising capital for colonial and post-colonial development, for supplementing and, in some cases, substituting for failures in private investment, are prominent in Australian economic development.

The second significant feature has been the linkage, from the earliest colonial period, to world commodity and capital markets. From the earliest date of settlement, exports of seal and whale products, followed by the expansion of agricultural, and later mineral commodity production, linked the Australian economy to world markets. As a colony of settlement rather than exploitation, immigration flows and a common European culture kept Australians aware of the latest scientific and technological developments. As the nineteenth century progressed, the application of science and technology occurred as an *intrinsic* part of Australian social and cultural development rather than as an externally imposed and alien cultural system. Both the *incremental, process-oriented* nature of Australian innovation and the *publicly funded* education and training institutions which developed should be seen as responses to these key features.

Australian development and the world economy: From colonies to federation

A common view of Australian development portrays a derivative society which, on the strength of agricultural and mineral exports in the nineteenth century, rode to early prosperity 'on the sheep's back' within a system of national protection and imperial preference. While there is some truth in this picture, the notion of a derivative society misses critical aspects of Australian development.

European settlement occurred as part of the Enlightenment, and absorbed key political and social lessons from the American and French Revolutions. Rather than a derivative science and technology, it is more productive to see Australian development in the nineteenth and twentieth centuries as occurring within mainstream western science and technology. In other words, innovation and technological development were absorbed, and lessons adapted within the constraints of limited population and markets in colonial and federated Australia; but they did not have to be adopted from 'outside'. This is a different process from technology transfer and diffusion which results from direct foreign investment in developing countries or in the 'Third World' countries and the newly industrialising economies.

Colonial science and technology

Australia was settled in the first stage of the Industrial Revolution when mechanical and civil engineering were the keys to technological development, and Britain and steam power reigned supreme (Williams 1987). It was not until the development of the new chemical and biological industries, particularly in Germany and France in the late nineteenth century, that basic and applied science became prominent in formalised research and development, and Britain was challenged for industrial supremacy. The strength of British manufacturing lay in its highly skilled artisans rather than in university-degreed engineers, and the source of improved technology was the informal and tacit skills of these individuals, as much as in original design or engineering blueprints. These skills, embodied in individuals, were highly mobile and able to be applied to the design, construction and modification of the basic machinery itself. That is, innovative processes developed from adaptations and new applications of existing mechanical technologies, rather than distinctly new technological breakthroughs.

In the colonial Australia context, the application of this mechanical and civil engineering technology was therefore rarely dependent on the importation of technological artefacts. In shipbuilding, for example, all of the necessary skills were available amongst the shipwrights of the First and Second Fleets, and many of the natural materials, such as timber, were at hand. Later migration was more a quantitative rather than qualitative increase in the skills base. Early limits to the permitted tonnage of locally built vessels imposed by an East India Company monopoly did not reflect a local lack of skill or knowledge and were soon abolished. In 1813 a skilled artisan had to be brought to the colony to assemble the first imported steam engine. By 1836 steam engines were built in Sydney for both manufacturing and marine use and imported engines modified locally for new applications. The latest metallurgical principles were applied in the earliest examples of smelting of copper and iron in the 1840s and applied in the development of locally produced agricultural equipment, including the cogs and gears for wind, water, animal, and later steam-powered grain mills (Linge 1979, pp.24–46; Birmingham & Jeans 1983).

By the end of the gold rushes of the 1850s a pattern of broad land agriculture was firmly established. Various colonial land acts passed in the 1860s certainly involved political conflict between classes and regional interests, but they also reflected the reality that early imperial visions of small-scale farming communities based on an idealised European model were not viable in Australian conditions. Capital-intensive, not labour-intensive pastoral and agricultural practices developed under the constraints of soil and climate, albeit mediated by individual and class ambitions, frequently theatrically displayed within a developing system of representative democracy. The agricultural expansion in wool, grain and animal products and later sugar, provided regional markets for a range of agricultural machinery that was substantially supplied by local manufacturers whose headquarters were based in regional areas. As Butlin (1962) has shown, manufacturing was increasingly important in local capital formation as the century progressed. This expansion of industry also diffused what were frequently informally acquired skills throughout the colonies.

The distillation of spirits and the growth of the brewing industry also provided a small group of artisans experienced in what we would now describe as industrial chemistry. Small scale and 'low tech' from our perspective, brewing became a significant industrial activity. Lack of refrigeration, and the vagaries of inland transport, spread this technology to regional centres. While brewing, fermenting and forms of distillation used in the preparation of alcohol raise images of the early rum trade, it should not be forgotten that it was from these processes that major breakthroughs in the understanding of bacterial processes were being made in Europe by, amongst others, Pasteur in France and Koch in Germany. At the turn of the century it was the application of this brewing technology, combined with industrial chemistry, metallurgy and the skills of a locally trained carpenter, EJ Lyster, that led to the development of the Potter/Delprat floatation process for metal extraction at Broken Hill, later adopted worldwide (Cull 1993; Blainey 1971, 1993).

Fermentation, and the practical and theoretical knowledge and skills involved were further developed within the technical colleges, institutes and medical schools of the universities. They provided a technical base for a range of biological production techniques, notably in animal vaccination, so that in the nineteenth century, an Australian anthrax vaccine developed at Narrandera in rural New South Wales was demonstrably more effective than that produced by the Pasteur Institute (Todd 1995). By the early twentieth century the new Commonwealth Serum Laboratories (Brogan 1990) could draw on both good scientists and adaptable technicians.

Cultural underpinnings

A printing press arrived with the First Fleet in 1788 and the first issue of the official *Sydney Gazette* in 1804 contained an article on the prospects for viticulture, translated from the French for the occasion. Plantings in the Hunter

Valley followed shortly afterwards. The first learned society in the colony was the Philosophical Society of Australasia, established in 1821, which in 1866 became the Royal Society of New South Wales. Each new colony, whether it separated from the original colony of New South Wales like Tasmania (1825), Victoria (1851) and Queensland (1859), or was settled separately like South Australia (1836) or Western Australia (1831), developed similar societies or clubs. These societies, whose journals provided wide coverage of international developments in the natural sciences and technology, as well as detailed reports of colonial investigations, provided a focus for colonial debates on education and training.

The politically well-connected members of these societies formed a network connecting the older mechanics institutes, schools of arts, new universities and emerging technical colleges and agricultural institutes. The geologist Archibald Liversage for example, who was Secretary to the New South Wales Royal Society for ten years, promoted the study of geology and mineralogy in schools. As a professor at the University of Sydney, and through his 1879 report on technical education undertaken while acting as the New South Wales representative at the Paris International Exhibition, he was instrumental in setting up formal technical education at Sydney Technical College and the associated New South Wales Museum of Technology. The establishment of the Melbourne Workingman's College in 1887 (later to become the Royal Melbourne Institute of Technology [Murray-Smith & Dare 1987]) and the South Australian Institute of Mining and Industry (the educator of Broken Hill Proprietary Company's Essington Lewis) and now the site of the University of South Australia, involved similar social networks linking prominent individuals and families (such as the Ormonds and Bonythons) with government and industry to develop technical education.

A slice through scientific publications in two symbolic years in Australian history, 1888 and 1901, shows that colonial society was abreast of international developments. The presidential address in the 1888 centenary edition of the *Journal of the Royal Society of NSW* was explicit in drawing readers' attention to local and international scientific and technological developments, and their potential application to industrial expansion. Also significant were the ten pages that noted recent additions to the society's library. These consisted of papers and journals from Britain, France, Germany, Italy and the United States. A similar involvement with the international scene is apparent in other colonial societies' proceedings. The mixture of reviews of the natural and applied sciences and advocacy of systematic technical and scientific education to be funded by the colonial state continued the theme that the New South Wales society's secretary, Archibald Liversage, had pushed over ten years earlier when he had been instrumental in setting up the New South Wales Technical Education Board.

The colonial situation contrasted with that of the metropolis. In the previous year (1887), TH Huxley had argued in the British journal, *Nature*, for the

extension of technical training in Manchester. Like many others, he was influenced by the coordinated approaches to technical education and training developing on the continent. However, in the United Kingdom, local administration continued to set the standards in both school and technical education, unlike the systems on the continent or, from a far smaller population base, those in the Australian colonies. Indeed, the United Kingdom had to wait for the Manpower Services Commission in 1960s 'before attaining the nearest thing to a national system the country had known' (Gospel 1994).

The contrast between the United Kingdom and colonial experience can be illustrated at another important symbolic date—Federation in 1901. In its January 1901 issue, the scientific journal *Nature* expressed grave concern about the case Regina v. Cockerton. This case, extensively covered, appealed against an action of a London school board which had disallowed expenditure for materials and equipment for the teaching of art and science. Deploring the ad hoc decisions of local administrations, and in the hope that the matter would proceed to appeal to the Privy Council, the editors of *Nature* concluded:

> *But whatever may be the present state of the law, one thing the case makes transparently clear, and that is the chaotic state of English education.*
>
> (*Nature* 1901)

The editors of *Nature* were to be disappointed. By contrast, in Australia by the end of the colonial period, the state of technical education may be described as under-funded, but not chaotic. While there were differences amongst the colonies, these were fewer than the similarities.

Colonial divergence

The Australian colonies had established free and secular education, at least to primary level by the 1880s. Universities had been established in Sydney (1850), Melbourne (1853), South Australia (1874), Tasmania (1890), and in the early twentieth century, Queensland (1909) and Western Australia (1910). Notwithstanding their sandstone buildings and architectural references, these universities were modelled not on Oxford or Cambridge, but on the new University of London, which like continental Europe, and in particular, Germany, emphasised the study of the natural and applied sciences and technology. Chairs were established in the basic sciences and medicine, which became the focus for research on human health at Melbourne, and animal husbandry and disease prevention at Sydney. An early graduate in engineering at Melbourne University in 1866 was WC Kernot who became the first Australian-born professor of engineering in 1883 (Moyal 1986). Although primarily focused on undergraduate teaching until after the Second World War, doctoral candidates were accepted in science at Melbourne as early as 1887.

Nevertheless, secondary education lagged and was almost exclusively the domain of the private church schools until the early twentieth century. However, this was balanced in part by the major growth of technical education colleges

and institutes in all colonies. Primarily through part-time evening courses, these substituted for a technical secondary system. Schools of agriculture were established at Roseworthy (South Australia) in 1884, Dookie (Victoria) in 1885, Hawkesbury (New South Wales) in 1888 and Gatton (Queensland) in 1898. The first institutes and schools of mines were established: Ballarat (Victoria) in 1870, Bendigo (Victoria) in 1873, Gawler (South Australia) in 1888 and Zeehan (Tasmania) in 1893. Thus, while technical education within the school system had to wait until the expansion of state secondary education in the twentieth century, a strong network of state-funded technical training institutions, providing large components of what we would now term vocational education and training, was in existence by the close of the colonial system.

In education and training, the direct involvement of the state set the stage for post-Federation development. But the process was not simply an imposition of state authority. Representative government and a range of important individuals such as Peter Board in New South Wales and Frank Tate in Victoria, all left the imprint of their individual personalities. Colonial bureaucrats and officials were also well aware of the latest 'progressive' educational theorists in North America as well as continental systems of technical education, particularly those of Germany, even if they frequently did not have the resources to fully implement their ideal schemes. In school education, textbooks tended to be sourced from the Irish National system, rather than English local authorities. In the technical education system, while standards and certification such as those provided by the London City and Guilds were widely used, newer industrial processes from Europe and North America entered the curriculum, particularly in the various branches of engineering. In general, the approach of the technical education authorities mirrored the approach adopted in local industry. While local industry reproduced occupational titles derived from the United Kingdom, it developed its technological capacity based on the most appropriate North American or European models. This was evident in the growth of the steel industry in Newcastle, which in the 1920s was one of the most modern and productive in the world (Blainey 1971). Financial capital was generally sought from London; however, intellectual capital and technological expertise were more widely appreciated, sought and applied.

Invention and innovation in Australia: Some examples

'Invention' has played a large role in Australian popular culture, with some leading inventors and scientific figures, William Farrer (1845–1906) and David Unaipon (1872–1967), celebrated on banknotes and in social studies curricula. The stump-jump plough (1876), the combine harvester (1885) and 'Federation wheat' were significant in agriculture. Lawrence Hargraves's (1850–1915) experiments with flight in 1894, the Potter/Delprat flotation process for the extraction of zinc (1904), Anthony Mitchell's invention of the thrust bearing

(1905), the original development of commercial refrigeration by compression in Geelong by James Harrison in 1850 and its successful application to meat exports from Sydney in 1879, the first production line 'ute', a Ford in 1937, and the humble rotary mower (1952–53) and Hills hoist (1948) are amongst well-known technical or industrial examples (Cull 1993).

More scientifically advanced inventions or innovations include the Commonwealth Scientific and Industrial Research Organisation's role in the development of the atomic mass spectrometer (1954), the Interscan aircraft landing system (1991), heart pacemaker (1929), gene shearing for genetic engineering (1987) and the bionic ear (1978). Recent green-friendly inventions include the development of Synroc for atomic waste disposal (1978) and the laser-grooved solar cell which is continuing development at the University of New South Wales (Cull 1993; Moyal 1986, 1987; Blainey 1978). These do not cover all innovations and major industrial process technologies assisted by the Commonwealth Scientific and Industrial Research Organisation and technical staff from the state technological museums and major technical colleges (Schedvin 1984; Mellor 1958).

The capacity to translate invention into production in either innovative products or processes is not, however, simply a matter of inventiveness, or even the availability of suitably motivated and cashed-up venture capitalists. The extent of product, labour and capital markets and the existence of appropriate social and technical infrastructure are crucial. Notwithstanding constraints imposed by population, a small domestic market and the 'tyranny of distance', the process of product and process innovation in Australia demonstrates the integration of Australian industry within the world scientific and technological community, supported by high levels of technical competence and adaptability in the domestic workforce.

Imported and locally developed skills

Skilled migration has always been a major contributor to the Australian labour force. Ann Moyal has argued persuasively that the majority of the early inventors were trained in Britain, and that consequently, in Australian colonies:

> *… there was little official impulse for the training of that important army that TH Huxley had called 'the foot soldiers of Science' … [however] … The 1880s saw the beginning of educational change.* (Moyal 1986, p.171)

Despite some technical difficulties in defining 'skilled labour' in nineteenth-century migration records (see Linge 1979, appendix, for a technical discussion), on average, there has been an excess of skilled and semi-skilled migration over unskilled migration for 120 years. However, this is best seen as complementing, rather than substituting for local skill formation practices.

Until the direct involvement of the colonial states, first in primary, and then in technical education in the 1870s, skill formation and transmission occurred

informally on the job, and skill diffusion through mobility in a tight, skilled labour market. However, from around the 1840s onwards, mechanics institutes and schools of arts began to play a role in diffusing skills. Murray-Smith (1987) for example, locates the origins of technical and further education (TAFE) at least partially in the system of institutes. Although they were rarely organised along coherent discipline lines, important institutions, particularly in Victoria, such as the Ballarat School of Mines, did develop from the local mechanics institutes. On the whole, the offerings of the institutes and schools were like the curate's egg, good in parts, but did not compare with the more formal and structured programs which developed later. Nonetheless, Todd's assessment of their value is realistic:

> *… the cultural infrastructure (of science and technology) comprised organisations often regarded as ancillary … but able to draw on a broader base of social support. The mechanics' institutes formed the backbone of this infrastructure with their object of the 'diffusion of Science and other useful knowledge'. … By the late 19th century there were about 1000 organisations in the Australian colonies.* (Todd 1995, p.29)

The mechanics' institutes, schools of arts, schools of design and schools of mines also provided an 'organisational core' around which subsequent formal technical education was moulded, as 'industrial developments forced governments to extend their educational responsibilities in the latter part of the century' (Todd 1995, pp.27–8).

If artisans were the 'foot soldiers' of science and technology, then the technical colleges and institutes, the schools of mines and industry and the agricultural colleges were the source of the even more critical non-commissioned officers of industry. The universities provided a small but significant research capacity, particularly in the medical and agricultural sciences. However, entry to university depended on matriculation which, with no state high schools in the nineteenth century, depended on a church or private school education. It was the more numerous tradesmen, upper-level artisans and certificated engineers of the technical colleges and institutes who provided the skilled nucleus for the development of public utilities and industries in the late nineteenth and early twentieth centuries.

This process was complemented by unique Australian institutional developments in the apprenticeship system. Colonial apprenticeship had followed the English model of on-the-job training delivered (if at all) by the employer, and struggled to survive. However, with Federation, the Commonwealth's industrial powers were used as part of a wage-setting mechanism, to define through awards, the minimum skill descriptions for key occupations. State industrial law generally followed federal leads. In practice this meant that, in the twentieth century, the Australian apprenticeship system adopted a Germanic rather than British approach, albeit within different legal and institutional structures. The Australian apprenticeship system increasingly included mandatory formal off-the-job apprentice

training to be delivered by a technical college system which, constitutionally, was a state not a federal responsibility.

However, the technical colleges, particularly the large colleges and systems, were not restricted to 'trade' or 'engineering' subjects and were remarkably cosmopolitan in their courses. For example, the 1898 calendar of Sydney Technical College listed amongst the courses on mechanical and civil drafting, chemical and electrical engineering and higher-level certificates in the construction, printing and mechanical trades along with courses in French and Indian cuisine. There was also a large range of business and accounting subjects and certificates which attracted the daughters of the middle classes. And, in a display of mutual recognition that would not be repeated for almost a hundred years, satisfactory completion of the plumbing trade certificate at Sydney Technical College was sufficient for recognition by the relevant statutory authorities in all other Australasian colonies, including New Zealand (Sydney Technical College 1898).

Although the technical colleges and institutes, in conjunction with the museums of science and technology, undertook applied industrial research at an equivalent level to the less numerous universities, forms of instruction and the status of employment differed. In the technical education system, part-time study was common and frequently undertaken at night. Students were usually employed and, also unlike the university system, a relatively small core of full-time staff were supplemented by part-time instructors and lecturers, frequently technical college graduates themselves, recruited from local industry. This exchange of skilled and qualified personnel between the technical colleges and institutes, large public sector utilities and both large and small employers, created an institutional framework within which technological innovations, generally process-oriented, could be diffused. In the process, late colonial investment in education and training took on a pattern still familiar today. Investment in formal skill formation (or human capital) was primarily a government activity, which in contemporary economic terms, could be regarded as a 'public good'. This was supplemented by far smaller individual private investment through student fees and forgone earnings during training. Investment by the private sector was limited, although representatives of private firms were both active and vocal in college and course committees.

'Tethered to the world': Federation to the Second World War

In 1898, Henry Lawson lamented that:

> *Those golden days are vanished, and altered is the scene;*
> *The diggings are deserted, the camping grounds are green;*
> *The flaunting flag of progress is in the West unfurled,*
> *The mighty bush with iron rails is tethered to the world*
>
> (Lawson 1898)

With these lines he summarised the substantial changes in Australian society which had occurred over the previous 40 years. Minerals were still a significant export, but the day of the individual digger had passed. 'Progress', while still linked to primary sector commodity production, was tied to an agriculture that was increasingly science and capital-based, with employment in both sectors in decline. Both mining and agriculture were supported by a manufacturing sector that produced industrial products, ranging from fertilizers to agricultural machinery. A rail, and increasingly mechanised road transport system and a telecommunications infrastructure did indeed tether commodity production to world markets. The days of the individual itinerant, often a self-trained mechanic or 'journeyman' were, like the digger, numbered.

Federation of the Australian colonies occurred in the aftermath of the depression of the 1890s, and education and training assumed an important role in the development of, in Alfred Deakin's phrase, 'a nation for a continent'. European and North American developments were followed in local journals, government reports and parliamentary debates. Notwithstanding statements of imperial loyalty by administrators and bureaucrats, their caveats made it clear that the preferred models were seldom those of the 'mother country'. In Victoria, for example, the 1901 Fink report analysed the requirements of technical education in the new century from a perspective that accepted the necessity to generate technical skills according to local needs (Barcan 1980; Todd 1995). In New South Wales a major overseas mission to Europe in 1902–03 returned with the clear view that:

> *What is really required is, (a) definite recognition of the economic value of a sound system of technical education …*
>
> *… In Europe technical schools were founded* in anticipation *of requirements, and have practically been the means of creating industries. Here the method is* to wait for a demand*, for some special form of instruction, and then to provide it imperfectly.*
>
> *… One cannot study the Technical Schools of Germany … and fail to recognise that there is a belief in the national value of all forms of education that is if not wholly wanting in us, is at least sadly deficient in comparison.*
>
> *… Germany's provision for higher,* technical*, secondary and primary education expresses, in a vivid and practical way her belief that expenditure on the education of a people pays, and is the necessary foundation for great national success …*
>
> (New South Wales Government 1905, pp.186–7, emphasis in the original)

While Commissioners Knibbs and Turner were largely disappointed in detailed implementation, their general recommendations (primarily Knibbs's) to introduce such innovations as 'sandwich' and shortened apprenticeships, and their commentaries on the changing requirements for skills, anticipate equivalent sections of the Carmichael, Finn and Mayer reports by 90 years. In

orientation, they were not dissimilar to conclusions of other states, such as the contemporary Victorian Fink report. Despite funding limitations, all states expanded the range and depth of courses offered to complement developments in both the blue- and growing white-collar occupations. Interestingly, some 80 years later, another overseas mission, *Australia reconstructed* noted:

> *In Sweden, skill formation is promoted by devoting substantial resources, both public and private, to training and retraining throughout a person's working life. In West Germany and Austria, the vast resources invested in the dual system of workplace and vocational training demonstrate those nations' commitment to the development of a highly skilled workforce.*
>
> (Australian Council of Trade Unions & Trade Development Council 1987, p.xiii)

In this light, recent accounts of major structural changes in the Australian economy following the oil crisis of the 1970s and the supposed imperatives of 'globalisation' in the 1990s may perhaps more realistically be interpreted as an acceleration of longer-term structural trends commencing in the late 1890s and continuing throughout the twentieth century. Productivity in Australia has continued to increase in commodity production and manufacturing, although the proportion employed in these sectors has been in long-term decline. The growth of the white-collar workforce at the expense of agriculture and mining occurred early last century and reflected a changed social structure in which administrative and clerical occupations began to increase in the capital cities and regional centres (see Withers 1989, tables). Significantly for future development, all sectors were serviced by a range of technical education and training institutions which ranged from operative to technician to professional levels.

The significance of the Constitution

The constitutional compromises negotiated between the parochial approaches of the former colonies and the claims of the new nation included two aspects that were to affect developments in technical education and training until the post-Second World War period.

The first was, that education, and therefore also technical education and training, remained a state responsibility. Indeed, until the transfer of income tax rights to the Commonwealth during the Second World War, the Commonwealth Government was not in a position to fund education from its limited revenues. This led to different institutional developments in the various states, most particularly in New South Wales and Victoria where technical high schools developed to an extent that they eventually formed a significant component of the new TAFE system introduced in the 1970s. The financial demands of an expanding high school system, a system which all states began to develop from the early years of the twentieth century, shifted the emphasis from, and limited investment in, separate technical education institutions. However, growing

professionalisation and the changing structure of industry all gave impetus to new courses and new colleges, although these seldom matched the wishes and demands of individual champions of technical (and other forms of) education. While the various states guarded and developed what they tended to perceive as unique, and sometimes uniquely superior arrangements, much of the difference was more apparent than real. The technical education institutions functioned to produce persons skilled in occupations, defined by the needs of external labour markets. As a consequence and unlike school education, a focus on defined skill and knowledge outcomes rather than pedagogy was always the primary concern of technical colleges and institutes.

The second constitutional arrangement which affected the technical education system was the Commonwealth responsibility for industrial disputes which extended beyond the borders of a single state. Coordinated actions between unions, employer associations or both made it relatively easy to manufacture an interstate dispute at will. Mr Justice Higgins, in the 1907 Harvester decision involving the Victorian company famous for the manufacture of the combine harvester, may indeed have introduced a 'new province of industrial law', with its determination of a minium basic wage sufficient to support a family. In an important sense this introduction of a 'social wage' was also a de facto industry policy. Unless an enterprise was able to pay the socially defined 'living wage', it could not operate. In practice it was a 'high-pay high-skill policy' but developed within a domestic market and behind protective tariffs. Margins for skill were applied within and across awards so that industrial law functioned to underpin occupational structures. The subjects and courses developed and offered by the technical education system throughout the twentieth century continued to reflect that basic occupational structure.

Despite a world war which cost 60 000 Australian lives sandwiched between two major depressions, the sophistication of the production techniques and the distribution of skills in the population continued to grow. In this, the technical education systems were significant. An indication of this importance can be seen from a longitudinal survey of the workforce conducted in the 1970s by the Australian National University. By dividing the 1971 workforce into age groups, it was possible to identify the source of formal qualifications. Although the skill level breakdown is somewhat crude, table 1 shows the relative importance of qualifications at 'trade' and 'technician' level obtained through the various state 'tech' systems, compared with 'tertiary' qualifications (including teaching certificates and the like).

It is also interesting to note the increase of 'tertiary non-degree' qualifications, which were primarily the areas targeted by the first post-war expansion of colleges and institutes of advanced education. The table indicates that, despite the Great Depression, a fairly effective, if under-funded technical education system provided a skill base able to support the rapid industrial expansion during the war, and the post-war 'boom' which followed.

Table 1: Source of qualifications in the Australian workforce: 1930–1960, percentages

Qualification	Years			
	pre-1929	1929–1938	1939–1948	1949–1957
Trade level	31	38	41	46
Technical level	12	12	15	17
Tertiary (non-degree)	0	5	7	8
Tertiary (degree)	0	3	2	3
	n = 201	n = 413	n = 514	n = 556

Source: Adapted from 1972 Australian National University Longitudinal Survey, in Hatton and Chapman (1989, p.131)

War and reconstruction to Kangan

The experience of the Pacific War demonstrated the depth to which technical and scientific skills had become embedded in Australian industry and the industrial workforce. In particular, it showed the strategic significance to the country and to industry of the technical education system, and the depth of skills of its professional and technical staff.

The economy was redirected, not just to increase munitions, but also to expand industrial employment and increase output through more effective chemical, electrical, mechanical and civil engineering processes. In this, the state technical colleges and their staff were critical. The contribution of the technical education system was not limited to training. Colleges and their staff were also directly involved with production, and the largest metropolitan and regional colleges contributed to total output by converting some premises to manufacturing facilities.

However, the key contribution was the role of the main colleges in supplying production tooling to external industry (see Mellor 1958; Blainey 1971). In a production environment 'the tools that make the tools' are critical. High levels of theoretical and practical applied knowledge are required. During the war it was not merely existing industries or industrial processes that were integrated with the technical colleges and technical college staff. Whole new processes and industries, such as the optical industry, were developed or greatly expanded. By the early 1940s, Australian industry was (with the exception of some specialised areas which relied on rare earths) virtually self-sufficient at design and production levels.

This wartime success should not just be seen as an issue for nationalistic self-congratulation. What is important is why and how it was achieved. The argument in this chapter is that it was made possible because it grew directly out of the real structure of Australian industry and industry's relationship with the technical education institutions. Import substitution, market constraints, broad-based skills, familiarity with modern technology and production

processes and a need to adapt to local conditions, together meant that innovation in Australian industry generally occurred through the extension and modification of existing technologies to new purposes. This typically relies on 'trade' and 'para-professional' level engagement with production, rather than research and development departments. It is this level that the Australian technical education system had developed to serve.

Evidence to support this analysis is provided in the context of the planning for a proposed institute of technology (now the University of New South Wales) in Sydney during 1947–49. A report was commissioned to compare the education and training provided to engineers by Sydney Technical College and found that, in terms of content, the course for certificate engineers at the technical college was equivalent to those of London University, Edinburgh University and the Massachusetts Institute of Technology, and of generally longer duration. Importantly, the technical college courses also included modern production engineering subjects, based on North American practice, which British universities did not really adopt until much later. It should be noted that the standards for certificate engineers in other states, also taught in the technical education system, were similar to those of Sydney Technical College. They had to be. Notwithstanding state differences amongst the departments of education, the colleges were all supplying the same occupations, engaged with the same organisations and professional associations, and therefore developed curriculum directed at the same needs.

The immediate post-war period saw significant Commonwealth funds allocated to retraining returned service personnel in both the technical education sector and the universities. However, by the beginning of the 1950s, the policy emphasis at state and federal level had shifted to higher education. Many of the upper-level courses in the technical colleges were transferred to existing and emerging higher education institutions. Post-war migration, particularly skilled migration, supplied both new labour and stimulated demand. Technical education became somewhat of a poor relation to other education sectors. New South Wales and Victoria in particular took different paths, with New South Wales developing a separate Department of Technical Education after 1949 and a Department of Education responsible (especially from the 1960s) for a comprehensive high school system. Victoria by contrast, expanded and developed a technical high school system which later merged into TAFE.

Kangan to the present

From the 1970s successive Commonwealth Governments moved towards the establishment of a national training system. In 1973 the new Whitlam Government established the Australian Committee on Technical and Further Education chaired by Myer Kangan. Its report, *TAFE in Australia* (Australian Committee on Technical and Further Education 1974), also called the Kangan

report, is generally considered a 'milestone of great and enduring significance ushering in the modern era of TAFE in Australia, defining TAFE as an alternative sector of education and delineating the general role for the current VET sector in Australia' (Kearns & Hall 1994).

The Kangan report set the agenda for change, and the Technical Education Commission was established under the *Technical and Further Education Act* of 1975. The Fraser Government came to power in 1976 and the next 15 years were characterised by growth in TAFE systems, development of national policies and structures, and ongoing tension between the Commonwealth and states over policies, processes and funding (Goozee 2001). There were also important changes in the TAFE student profile, improvements in student financial assistance and the targeting of educational programs to disadvantaged groups.

The Hawke Labor Government's concern with structural reform of the economy and, in particular, the issue of unemployment, led to the appointment in late 1983, of the Committee of Inquiry into Labour Market Programs, chaired by Peter Kirby. The committee's report, released in 1985, made 86 recommendations, the most important of which was to develop a system of traineeships which would combine broad-based vocational education and training in an institution with work in a related occupation.

In the early 1990s, the Finn report, *Young people's participation in post-compulsory education and training* highlighted the tension between general education (assumed to be a broad range of transferable skills) and vocational training (assumed to be a very narrow range of competencies). The major theme of the report was that both industry and individual needs were leading to a convergence of general and vocational education. In addition, Prime Minister Paul Keating's 1992 economic statement ('One Nation') included a proposal for the Commonwealth to fully fund TAFE. It recognised that, compared with schools and universities, the TAFE system was under-resourced and growth was required to assist Australia to become more economically competitive. Conflict arose between the Commonwealth and the states and territories, and between states, over the funding of TAFE. However, it was agreed to jointly fund the national training system through the establishment of the Australian National Training Authority (ANTA) with the Commonwealth supplying growth funding for 1993.

Along with changes in all sectors of education in the late 1980s, for TAFE, there was the development of a 'training market', the move towards competency-based training and the push towards more specific 'skills formation' rather than broad vocational education and training. As Goozee (2001) notes, 'the coining of the term "skills formation" to replace TAFE and training gave a strong indication of the new directions which were to be taken in applying economic rationalism to vocational education and training', a process somewhat at odds with previous expressed beliefs about the convergence of general and vocational education.

As part of a newly created 'VET sector', TAFE needed to secure its share of Commonwealth funds and to market itself in an increasingly competitive environment. At the same time, the Commonwealth Government was committed to reducing unemployment and encouraging a commitment to training by business and industry. These and other factors contributed to what became known as the Australian Training Reform Agenda. In 1995 the government established a National Employment and Training Taskforce to assist in marketing new traineeships and a structured approval process for new traineeship packages involving all states and territories. The first national training packages were endorsed in 1997 and the packages cover the competency standards, qualification rules and assessment guidelines for an industry, although some, such as business services, are cross-industry (Smith & Keating 2003).

In 1993 the endorsement of the Australian Qualifications Framework was a major step towards a nationally consistent system of qualifications and awards. The framework, incorporating 12 levels of qualifications was introduced in 1995. Finally, the Australian Quality Training Framework was introduced in 2002 with the intention of again improving the quality of VET delivery. This framework contains standards which establish rules about how registered training organisations are to operate in order to gain and maintain registration, as well as standards for state accreditation authorities.

Conclusion

The last decade has seen significant changes to the administrative and funding arrangements of the formal VET system. However, an emphasis on change and difference at an education system level can mask ongoing continuities in industry itself. Notwithstanding the major structural changes in the Australian economy which have accelerated since the late 1970s, the Australian innovation system still primarily depends on process rather than radical innovation. Capacity has expanded, new production processes and products have been introduced and new markets for manufactured goods and tertiary services have developed. But the essential characteristics of an economy constrained by a relatively small domestic market have not significantly changed. This is not to denigrate Australian industry. As the Business Council of Australia remarked in the early 1990s, 'most innovation in all advanced economies is of this type'. It rejected as too 'narrow and misleading' the:

> *… conventional wisdom … that innovation equals invention plus commercialisation … Innovation is not science. Nor is it technology or the ownership of invention.* (Carnegie et al. 1993, p.3)

In practice, innovation comes from 'complex interactions between many individuals, organisations and environmental factors' rather than a 'linear trajectory from new knowledge to new product' (European Commission 1995, 1.5).

'From this perspective the development of "human resources" is critical, first for the *creation* of new knowledge (primarily basic science) and second for the *diffusion* of knowledge throughout society' (European Commission 2000, p.29). A skilled workforce is a key pathway through which diffusion occurs, and the development of this skilled workforce is, in general, the domain of VET institutions. This involves far more than a rationalisation of VET credentialling mechanisms.

The Australian system of innovation fits the pattern of incremental innovation and diffusion of technical knowledge. Historically, from colonial times to the advent of the present national system, the technical education and training institutions, for all their historically specific characteristics, industry critics and state differences have functioned to support this process. To respond to challenges of geography and climate, Australia depended on innovative local solutions to local problems and relied heavily on the skills supplied by the technical education system at 'semi-skilled', 'trade', 'certificate' and 'diploma' levels. Where constraints on the application of these skills occurred, it was generally as a result of industrial and work organisation issues in large hierarchically organised workplaces. Inability to apply skills for organisational reasons is not a failure of the training system to supply those skills.

Contemporary society is the product of historical process and Australia has, since European settlement, been 'tethered to the world'. The particular challenges of the twenty-first century are not likely to be met by reproducing training and industry models drawn from an idealised past (or for that matter an idealised future). The lesson that history can provide, however, is that technical and other forms of education in Australia developed in response to real, not idealised conditions. There seems little reason to suppose that the response to future needs, and the best policy base from which to judge that response, should be any different.

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Innovation and vocational education and training

Lessons from leading national innovation systems

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Governments tend to follow two approaches to fostering innovation. One approach is to offer a regulatory framework that supports innovation, such as legislation to protect intellectual property, but otherwise innovation is left to enterprises and is seen as a by-product of market forces and competition (Sheehan & Messinis 2003). The other approach recognises that enterprises rarely innovate alone and aims to consciously foster a national innovation system. This often takes the form of a network based on linkages between key inputs such as skilled personnel, government-funded research capacity and access to venture capital (OECD 2001). The tendency has been for Australia to follow the first route (Sheehan & Messinis 2003).

This chapter[1] seeks to identify the key characteristics of successful implementers of the second approach and to draw out the implications in particular for the vocational education and training (VET) system in Australia. Key conclusions are highlighted from case studies of national innovation systems in countries, including the United States and the United Kingdom (England), Korea, Finland and Singapore. The case studies illustrate the importance of a number of different aspects of the innovation process. These are discussed under three broad headings: understanding better the origins of the innovation process, key ingredients of a national innovation system, and specific implications for vocational education and training.

The case studies also highlight the important point that, while governments can provide incentives for more research and development, if enterprises are not able to respond by developing the product or service and bringing it to market, then the innovation process stalls. This situation is often said to hold true for Australia.

[1] A summary of the report, Curtain, R (forthcoming), *Vocational education and training, innovation and globalisation*, NCVER, Adelaide.

Introduction: Why international comparisons of national innovation systems?

PORTER (2003) HAS NOTED that, over the past quarter century, Australia has been transformed from a classical 'imitator' of others' innovations to a 'second-tier innovator economy' (Gans & Stern 2003, p.3). Gans and Stern conclude that, 'while Australia has improved its innovative capacity over time, it has not done so as fast as key international competitors'. Indeed some countries, such as Finland and Singapore, have started from a lower base than Australia and have leap-frogged ahead.

International comparisons, therefore, offer the potential for major insights into the missing elements of the policy framework, or those which are under-emphasised in Australia. The examples of Finland and Singapore in particular have shown the important role human capital[2] plays as part of a national innovation system in economies with strong track records in innovation. This chapter also considers the role of the vocational education and training sector in the innovation process.

Even though Australia is in the top six Organisation for Economic Co-operation and Development (OECD) countries for research and development expenditure in the public sector, business investment in innovation is far below other OECD countries, resulting in poor capacity to commercialise ideas (Gans & Stern 2003, p.41). Efforts to strengthen the links between science, research and development, industry and business in Australia have been at the forefront of recent government policy (Commonwealth of Australia 2001, p.19). However, in contrast to Australia, the case studies provide evidence of a greater sense of urgency underpinning the development of national innovation strategies in Finland in the early 1990s, and Singapore at present.

Understanding better the origins of innovation

Important role of research and development

The case studies show that research and development is a major contributor to innovation, generating a flow of technical ideas and continually renewing the pool of technical skills. In both Finland and Singapore, a high level of investment in research and development, by both public and private sources, has been an important feature of the climate promoting innovation. In Finland, for example, the volume of research and development investment over the past 10 to 15 years has grown more quickly than in other OECD countries, at an annual rate of about 10%. In 2000, the private and public sectors in Finland

[2] In human capital theory workers are defined as vehicles for the economic progress of the nation.

invested in research and product development at a rate of approximately 3.3% of gross national product, putting Finland at the top of the list of research and development investors.

International comparative data for 1998–99 show that Finland spent, in relative terms, twice the amount on research and development than did Australia (3.04% of gross domestic product compared with 1.50%). While government and higher education expenditure on research and development was very similar, the big difference in Finland's favour was in business-funded expenditure (1.94% of gross domestic product compared with 0.68%) (ABS 2002).

Finnish researchers are at the leading edge of developments in a number of fields, including forest improvement, brain research, neural networks, low-temperature physics, new materials, biotechnology, and genetic technology. Product development work has spawned numerous important and innovative new products. Finnish engineering companies have manufactured icebreakers, cruise liners, lifts, diesel engines, sailing yachts, compasses, fishing lures, frequency transformers, stone drills, harvesters, contraceptives, pipettes, and scissors and axes. Information technology-based products developed in Finland include internet encryption systems and the Linux operating system developed by Linus Torvalds.

In Singapore, research and development in electronics, engineering and life sciences has been important, with both public and private investment contributions. Singapore's research and development expenditure, expressed as a percentage of gross domestic product, has risen steadily from 0.9% to 1.9% between 1990 and 2000 (Government of Singapore 2002, p.60). However, in terms of outputs from the research and development process, Singapore's patents record is weak. While it has improved steadily over the last decade, from 25 United States patents in 1990 to 304 patents in 2001, Singapore's performance is still weak by international standards. Singapore registered 74 new United States patents per million population in 2001, whereas Canada and Taiwan had 131 and 294 patents respectively. Australia recorded 52 United States patents per million population in 2001. The United States ranked first with some 350 United States patents per million population (Government of Singapore 2002, p.61).

Enterprises in the life sciences in Singapore now account for the largest investment in research and development. The Singapore Government has underwritten the involvement of 'star scientists' with firms working in life sciences to help them to make commercial breakthroughs in biotechnology. The presence of a strong local research and development sector has been a prerequisite for attracting these 'star scientists' to work in Singapore (Asia-Pacific Economic Cooperation Economic Committee 2003, p.12).

However, research and development need not refer merely to the outputs of laboratory investigations, it can also refer to developing improvements to

existing products and processes, resulting in cost-cutting efficiencies, and hence making a value-added contribution to an enterprise.

This broader understanding of research and development suggests that vocational education and training providers can also be part of research and development efforts. This point is elaborated later in the chapter.

Innovation applies to more than high-technology industries

The experiences of the United Kingdom and the United States with the types of innovation that contribute to economic growth show that there is a danger of focusing only on those concerned with high technology. Other industries with technologies classified as 'medium-low' and 'low' such as petroleum refining, pulp and paper, textiles, or food and beverages, can also be highly innovative, drawing on many fields of knowledge (European Commission 2002, p.7). These sectors often innovate through the purchase of advanced manufacturing technology or by developing sophisticated production and delivery systems. In Europe, for example, several low technology sectors, such as food and beverages, are of far greater economic significance than high technology sectors, such as aerospace or pharmaceuticals (European Commission 2002, p.7).

The application of new knowledge and processes to such 'low tech' industries as vegetable production and marketing and office cleaning can have a marked effect on the success of an enterprise. In the case of a vegetable farming enterprise in East Gippsland, for example, the application of international best practice standards to genetic selection, fertiliser, water and pesticide regimes, harvesting and handling, has transformed a local producer into a leader in national and international markets. Also important in this enterprise have been changes to business management skills, logistics management, marketing, branding, quality management and staff training (Griffiths 2003, p.9). Similarly, more than 300 jobs have been created in a company in the same region as a result of its capacity to process fresh salad vegetables utilising modified atmosphere packaging, a new technology offering longer shelf life for fresh vegetables (Griffiths 2003, p.9).

A good example of the new recognition of the role of knowledge in generating processes for a labour-intensive production mode is the Danish company, ISS—International Service Systems. The company provides, among other facility services, commercial cleaning services in 38 countries. The company has built up a strong reputation for its attention to detail, supported by its extensive training programs. International Service Systems has more than 250 000 employees and more than 125 000 business-to-business customers worldwide and has recently expanded into Australia.

The potential for the application of new processes to medium and low technologies to outstanding effect has major implications for the types of markets traditionally served by vocational education and training providers. VET providers need to be aware of and involved in the development of new

processes to ensure their incorporation in the training services on offer. Waiting for a process to become well established in an industry sector before it is offered as a course based on standardised competencies may ensure that the VET sector has little relevance to innovating enterprises.

Aiming to be at the forefront of developments suggests that the shelf life of courses needs to be short, with constant revision to content built into the design of the course. Scope is also needed to develop entirely new courses based on new processes which have been recently developed. How this might be done is discussed in the concluding sections of the chapter.

Innovation is driven by enterprises

The outstanding success of Finland's Nokia in becoming a world company within a decade suggests that enterprises, not governments, are at the heart of the innovation process. These are the entities which take new ideas, turn them into a product or service and then market the result. In Korea, four conglomerates, Hyundai, Daewoo, LG and Samsung, account for over half of the country's exports. Multinational corporations play the same role in Singapore and in Australia (Toner et al. 2004). However, it needs to be acknowledged that, in both Korea and Singapore, small and medium-sized enterprises find it much more difficult to survive and prosper.

When the enterprise is seen as the key agent of the innovation process, a broader definition of what constitutes innovation can be applied. Enterprises also practise incremental innovation—as they seek out ways to update their products and processes. An enterprise may innovate by taking an idea from another business sector and adapting it for use in its own production processes or market. Examples include the use in the automobile industry of high-performance materials originally developed for aerospace applications, or the spread of computer-aided design into the textile and garment industries.

The search for new, untapped market space is another driving force. This may rely on technological innovation, or on reconfiguring existing products and services in order to present a radical change which will be perceived by customers as offering more or better value ('value innovation'). The 'reinvention' of the wristwatch as a low-cost fashion accessory is an example of this form of innovation which was not technologically demanding (European Commission 2003, p.6). It may also be realised through the introduction of a comprehensive new approach to a business, such as the new business models of online retailers, with the objective of creating new market space, or increasing profitability in an existing market (European Commission 2003, p.6).

Organisational change is another source of innovation. New ways of organising work, such as workforce management by involving employees in ways to make the workplace a collective resource for innovation, and/or improved systems of distribution, finance, manufacturing, or other aspect of an organisation's operations, can also have a positive influence on competitiveness.

Presentational innovation is another term used to refer to innovation in areas such as design and marketing (European Commission 2003, p.7).

Innovation defined as 'organisational change' or 'presentation change' provides obvious openings for the involvement of VET providers.

Importance of a national sense of urgency on need to promote innovation

The promotion of innovation by the Government of Finland in the 1990s as a national strategy was a direct response to the dramatic and painful changes following a number of important structural shifts experienced by the Finnish economy in the early 1990s. These included the disappearance of Finland's status as one of the main western gateways to the Soviet Union's economy. Output growth dropped from an annual rate of 5.1% in 1989, to 0% in 1990, and then plunged to -6.3% in 1991. Unemployment rose from 3.2% in 1990, to 6.6% in 1991, peaking at 16.6% in 1994.

By the end of the decade of the 1990s, a substantial turnaround had been achieved, with much of the growth coming from high-technology products, in particular from telecommunications equipment. As a result of the increasing specialisation in high-technology sectors, Finland's trade balance in high-technology products turned from a large deficit in the early 1990s to a significant surplus by the year 2000 (Blomström, Kokko & Sjöholm 2002, p.8).

In relation to Singapore, the relocation of electronic and other manufacturing facilities to lower-cost countries such as China and Malaysia in the 1990s has resulted in massive job losses, with unemployment reaching a 17-year high in 2002. The small island state with no natural resources other than its location has turned to the high-technology biomedical sector to generate new growth.

Other areas designated as having the potential for growth are high value-added activities in photonics, nanotechnology, alternative fuels and performance materials.

However, a major constraint on moving into new high-technology areas is the need for a broad and deep skills pool.

Key ingredients of a national innovation system

A supporting environment is required

The capacity of enterprises to be innovative depends on the supporting environment in which they operate. The fluidity of knowledge flow between individuals, firms, organisations and also between national economies is a key feature of a supportive environment. Knowledge networks reduce the cost of research and development and speed up the innovation process. Empirical studies have shown the success of collaboration in the discovery, application

and diffusion of technologies. Foreign direct investment has been recognised as a means of importing innovation (OECD 2000; Toner et al. 2004).

The development of clusters of excellence, when there is a conjunction of factors, such as infrastructure, availability of skills and expertise, research and technology centres, and enterprises with innovation potential, is of paramount importance for innovation performance. However, the case studies also demonstrate that a government's role in promoting innovation has to go beyond simply providing incentives or funding more research and development.

The Finland case study indicates that innovation arises from complex interactions between individuals, organisations and their operating environment. An essential element of an enterprise's capacity to innovate in Finland and Singapore has been a set of interactions with other enterprises, organisations and public bodies. Enterprises seeking to be innovative rely on external inputs, in the form of skills, advice, proprietary technologies, cooperation networks etc. (European Commission 2003, p.8). These external links are often best provided by clusters of like-minded enterprises—geographic concentrations of complementary, interdependent, yet competing enterprises, their suppliers, service providers and associated institutions.

Importance of skills

The country case studies of Finland and Singapore (Curtain forthcoming) demonstrate how reforms to skill formation processes are an important element of their governments' efforts to promote national innovation systems. An enriched skills pool is a central feature of the innovation process. The knowledge and learning capacities of people are instrumental for innovation processes, as are their powers of creativity, initiative and drive, determining to a large extent, the innovation capability of organisations.

Indeed, the absence of appropriate skills is a major constraint on growth. High-technology companies in Finland still suffer from a chronic shortage of educated labour: 'total employment in the cluster would certainly have been much higher without this restriction' (Blomström, Kokko & Sjöholm 2002, p.18). Evidence of skill shortages in high technology enterprises still underpins the pressure on the Finnish Government to improve the efficiency and effectiveness of the higher education system.

Singapore has also sought to foster a highly skilled workforce as part of its strategy to attract foreign direct investment in high technology industries. The Government of Singapore has recently invested heavily in tertiary education by setting up a third university (the Singapore Management University). It has also increased enrolment in the two existing universities by establishing multiple campuses specialising in various disciplines, as well as expanding Nanyang Technological University beyond its focus on engineering to offer a comprehensive range of courses.

These reforms have focused not only on identifying the new skill sets needed, such as composite skills, especially related to new blends of technology, but have also involved establishing arrangements for developing these skills which are very different from those required in industrial models of development.

What sorts of skills?

Innovation requires a system of skill formation, according to the OECD and the World Bank Institute study entitled *Korea and the knowledge-based economy: Making the transition*, based on continuous learning (Dahlman & Anderson 2001). This system includes providing basic skills to those who do not have them. It also requires developing core skills which encourage creative and critical thinking for problem-solving for those with technical skills, as well as developing additional specialised skills for those already possessing high-level technical skills.

According to the OECD and the World Bank study, successful implementation of a 'cradle to grave' approach displays four characteristics:

- Individuals are motivated to learn on a continuing basis.
- They are equipped with cognitive and other skills to engage in self-directed learning.
- They have access to opportunities for learning throughout life.
- They have financial and cultural incentives to participate in lifelong learning.

The lifelong learning approach needs to be centred on the learner and include collective entities such as the enterprise, the economy and society at large, as well as the individual. The objectives of education policy in this new environment need to be defined in the broader social and economic context and take into account individual objectives as they change over the lifecycle.

As noted above, the skills required to support innovation need to have a solid theoretical basis to engage in problem-solving. This means that, where the development process is open-ended and often uncertain in terms of future direction, standardised skills common in routinised maintenance work or rule-driven production systems are no longer needed. The new focus is on a skill set to underpin the economic drive to innovation which is multifaceted and ever-changing.

According to Richard Florida's analysis of the 'creative class':

> *The key difference between the Creative Class and other classes lies in what they are primarily paid to do. Those in the Working Class and the Service Class are primarily paid to execute according to plan, while those in the Creative Class are primarily paid to create and have considerably more autonomy and flexibility than the other two classes to do so.* (Florida 2002, p.8)

Florida defines the 'creative class' to include people in science and engineering, architecture and design, education, arts, music and entertainment, whose role it is to create new ideas, new technology and/or new creative content. Also said to be associated is a broader group of creative professionals in business and finance, law, health care and related fields. 'These people engage in complex problem-solving that involves a great deal of independent judgment and requires high levels of education or human capital' (Florida 2002, p.8).

However, Florida also acknowledges that creativity in the workplace is not limited to members of the 'creative class'.

> *Factory workers and even the lowest-end service workers always have been creative in certain valuable ways. Also, the creative content of many working-class and service-class jobs is growing—a prime example being the continuous-improvement programs on many factory floors, which call on line workers to contribute ideas as well as their physical labor. On the basis of these trends, I expect that the Creative Class, which is still emergent, will continue to grow in coming decades, as more traditional economic functions are transformed into Creative Class occupations.* (Florida 2002, p.8)

In Singapore, skills deficits identified include a lack of creative engineers, senior managers and low skills operatives in manufacturing and in services and a lack of creative professionals in advertising and media banking services (Singapore Ministry of Education 2003). There is also said to be a lack of entrepreneurs and risk-takers (Brown, Green & Lauder 2001, p.40).

An additional set of skills highlighted as crucial to promoting innovation are those related to entrepreneurship. In Finland, the need for the polytechnics to provide education in entrepreneurship skills from the small-to-medium enterprise point of view was identified as an important focus in the new arrangements. The polytechnics were required to take a central role in improving small-to-medium enterprise operations and entrepreneurship.

The dearth of entrepreneurial skills in Singapore has been recognised: 'Singapore needs entrepreneurs to create new business models based on the new discoveries and to challenge existing firms to innovate'. A government committee has proposed a comprehensive set of initiatives for nurturing entrepreneurship. These include promoting greater creativity in the education system, attracting global entrepreneurial executives to Singapore as 'mentors', the development of the venture capital market, as well as making the legal environment more conducive for new start-ups.

New skill formation arrangements

Both Finland and Singapore have substantially upgraded their systems for providing technical skills. In Finland, the demand for higher-level technical skills led the government to reform its vocational education and training sector. Provision of vocational education had been divided into separate fields, each

with its own schools and institutes. These were often very small and there was little cooperation between fields of study. The Finnish vocational education system was difficult to describe and grasp, and in particular, there was little understanding of the role of post-secondary vocational education and its standing (OECD 2003, p.50).

The aims of the reforms in the vocational sector were three-fold and were designed to:

- provide an alternative route into higher education with a more practical emphasis, alongside the universities
- increase the international comparability of vocationally oriented higher education in Finland
- strengthen regional development and co-operation with small-to-medium enterprises.

(OECD 2003, p.139)

The changes involved setting up new institutions in the form of tertiary-level polytechnics with a strong emphasis on good performance and high-quality outputs. This was done by upgrading the qualifications of staff and engaging in research and development. The mission of the polytechnics states that they are 'to engage actively in the development of working life and to produce relevant new knowledge'. Another aim of the reform process was to set up institutions in locations where they could promote regional development (OECD 2003, p.110).

Both compulsory education and post-secondary education still maintain separate technical education streams in Singapore. The secondary school system incorporates a technical stream to Year 10 level which prepares students for study at the Institute of Technical Education or for apprenticeships. The curriculum focuses on proficiency in English and mathematics. An option exists for students from this stream to continue on to tertiary study as well.

Post-secondary technical education is provided by the Institute of Technical Education which took over the functions of the Vocational and Industrial Training Board of Singapore. In 2002 the institute had 17 468 students with 16% of the relevant age cohort graduating that year (Singapore Ministry of Education 2003). However, a greater number of students attend the five polytechnics, established from the early 1990s onwards. In 2002, there were 54 689 students studying at the polytechnics, with 35% of the relevant age cohort graduating from a polytechnic (Singapore Ministry of Education 2003). The prominence of the new polytechnics suggests a similar pattern to Finland, where a desire to upgrade technical skills led to the establishment of polytechnics and the use of a range of incentives to encourage students to go to them.

Use of international benchmarks

International benchmarks for vocational education and training were used by the Finnish Government as a key element of its reforms for VET. This was done

to raise the quality of the education provided and to enable students to study abroad. The Finnish Government set an objective that at least one-third of all students in higher education should complete part of their degree studies abroad, with a focus on long-term exchanges lasting over three months.

The focus of lifting vocational education and training to international standards was important because graduates from the former post-secondary vocational colleges often experienced major difficulties in international mobility. Finnish polytechnic graduates, however, are said now to have no problem in going on to study or work abroad (OECD 2003, pp.126–7).

Focus on the workplace

An important part of the new arrangements involving the establishment of polytechnics in Finland is an emphasis on the 'actual needs of working life'. The practical goals of research and development in the polytechnics focus on creating new or improved products, production tools or methods and services. Research and development is also seen as an important way to improve the competence of the teaching in the polytechnics. Teacher knowledge is improved by the provision of opportunities for working more closely with a relevant sector. An important part of linking more closely to the workplace is through students' final year projects (OECD 2003, p.161).

The same emphasis on better linkages to workplaces can be seen in the new arrangements for the engineering degrees at Singapore's Nanyang Technological University. For 20 years a key element of the engineering degree has been a six-month industrial placement as part of the formal requirements for the degree. The placement is offered mainly in semester 2 of the third year.

A new focus in the industrial placements from 2003 is more emphasis on achieving designated learning outcomes. These refer to a range of possible suggested academic, professional, and personal outcomes (Ng & Loh-Goh 2003, pp.3–4). Each student during the first two weeks of the industrial placement is to develop a work plan with specific self-directed learning objectives. Students are to be supervised by a site supervisor, preferably an engineer, and an academic supervisor. Assessment is through scrutiny of a log book, an oral interview and a final report (Ng & Loh-Goh 2003, pp.5–7).

VET providers as intermediaries in clusters

Fostering closer ties between enterprises is an important role of the new regional polytechnics in Finland. Research and development is regarded as an important part of the services provided by polytechnics to the wider community and local economy. Polytechnics are expected to focus not only on new small-to-medium enterprises but also on traditional small-to-medium enterprises which have not undertaken research and development of their own.

Extending innovation and the principles and practice of research and development to this rather large group of small and medium-sized companies is seen as an important challenge for the new polytechnics. It is acknowledged that, in relation to innovation, the small-to-medium enterprises have particular problems in funding research and development. So the polytechnics are expected to provide expert help in developing research and development capacity in this group of enterprises (OECD 2003, p.120).

Another role set by the government for the new polytechnics in Finland is the promotion of regional development, and meeting regional needs for higher education. In most cases, the objectives of research and development at polytechnics have been linked to regional objectives, with an emphasis on supporting small-to-medium enterprises. As a result, they have become part of the regional innovation systems, which are concentrations of centres of expertise around institutions of higher education, national programs for centres of expertise, technology centres, science parks and other organisations benefiting from the expertise of higher education institutions (OECD 2003, p.110).

Education-based intermediaries are also prominent in industry or regional clusters in the United States. In Silicon Valley, for example, community or technical colleges play a key role in performing this function (Pastor 2003, p.35). Much of the training provided through the community college system in the United States is for new entrants to the labour market. However, community colleges also play a crucial role as labour market intermediaries for people who are returning to community colleges for mid-career training.

To help them perform their roles as labour market intermediaries, the community colleges in Silicon Valley have established contract training and economic development assistance arms. These provide customised training and assistance to firms in the region. Intermediaries based around community colleges with strong information and industry connections and the accessible delivery of a current curriculum provide the most promising models of intermediary activity (Pastor 2002, p.71).

These intermediary efforts by community colleges display specific characteristics. These include:

- ❖ targeting particular occupations or industry sectors
- ❖ maintaining communication with workers over an extended period
- ❖ building strong relationships with employers
- ❖ deliberately focusing on workers' long-term needs
- ❖ providing both formal training and informal on-the-job learning opportunities over extended periods of time.

One major benefit for the community colleges from closer ties with specific groups of enterprises appeared to be good prospects for job placement for graduates of their programs (Pastor 2002, p.71).

Specific implications for vocational education and training

Link vocational education and training to research and development

Research and development undertaken in the VET sector in Australia is not recorded in statistics collected by the Australian Bureau of Statistics (ABS). Statistics relating to higher education expenditure on research and experimental development specifically exclude 'non-university post-secondary education institutions (for example, technical and further education colleges) because it is considered that their contribution to total research and development activity would be minimal' (ABS 2003).

The example of Finland, in relation to its upgrading the quality of outputs of its vocational education sector, suggests that access to government-provided research and development funding may be one way to link the VET sector in Australia more closely to innovation. The Finnish example shows how use of research and development funding by the new polytechnics was directed to support for regional efforts to promote innovation with a sole focus on small and medium-sized enterprises.

The Finnish example also highlighted the use, in relation to the revamped VET sector, of a broader definition of research and development, focusing on processes and the development end, rather than on pure research.

Use of international benchmarks

The Finnish case study (Curtain forthcoming) also suggests that one way to raise standards in the vocational education and training sector is to use international benchmarks. The justification for this was not only to meet the needs of innovating enterprises; it was also undertaken to enable students to study abroad during their program of studies and to obtain a qualification which would be well regarded in innovation sectors of other countries.

Australia has been criticised for poor linkages to its neighbours compared with the Scandinavian countries:

> *… Australia is less connected to the innovative efforts of its neighbours. For example, while several East Asian nations such as Singapore and Taiwan have substantially enhanced their innovative capacity over the past decade, the key clusters in these countries are quite different than [sic] leading Australian clusters. Enhanced investments in the common innovation infrastructure, the innovation environment for clusters, and linkage mechanisms will be required for Australia to improve its innovative capacity position over the medium term.*
>
> (Gans & Stern 2003, pp.40–1)

One way for Australia to improve its linkages with other countries is to promote student exchange with its neighbours with strong innovative sectors, such as Singapore, Taiwan and Hong Kong, as well as Malaysia and Thailand.

Other opportunities for the VET sector to engage in knowledge transfer with VET systems in other countries with lively innovation sectors could also be explored, as exemplified by the exchange between Finland and the United States.

Use distance learning linked to innovation clusters

It is important that vocational education and training for the innovation sector provides students with skills in demand in the world economy. This is now possible using technology to access knowledge in textbooks which meet international standards. It is also possible to use distance learning to access courses in other countries on topics such as nanotechnology or biomedical sciences. The BioScience Workforce Development Centre, for example, has been funded by the State of California to assist the biotechnology industry to move from research and development and capacity-building activities, into production. This has been accomplished through the deployment of bioprocessing and biomanufacturing education, training, and direct technical assistance to companies. There may be scope for selected VET providers in Australia associated with biomedical clusters in Adelaide, Melbourne and Brisbane to link with this centre through the use of low-cost video-conferencing technology.

New skills need new training arrangements

Development of new training resources to supply the skills required will need to meet the following criteria:

- Course developers will need close ties to the innovating workplaces to understand what is required. This is likely to require some period in the workplace to absorb the tacit skills as well as the more standardised skills used.
- Participation in research and development projects may be an important way to identify the new skills required.
- Specific research and development projects may need to be undertaken by course developers to identify how 'high trust, high performance workplaces' pass on tacit skills.
- The turnaround time for developing a course may need to be short as the shelf life for the course itself may be short.
- Course developers may need to operate in institutional settings which are separate from traditionally defined disciplines in order to develop courses which may cut across the traditional boundaries. This may require being part of a virtual community of practice which operates across state and national borders.

- All students should have access to on-the-job training to ensure that their theoretical learning is workplace-grounded and often task-specific.
- VET providers also need to identify ways to foster entrepreneurial skills alongside other skills sets being offered. This was a feature of all the cases examined—entrepreneurial skills are an essential element in innovation.
- Teaching entrepreneurial skills may require use of different teaching techniques, including the use of real-life entrepreneurs to provide a better understanding of what risk-taking does and does not involve.

Vocational education and training providers as innovation cluster intermediaries

The case study of Finland and the example of the regional clustering in the United States suggest there is considerable scope for VET providers to act as intermediaries. As noted in the case of Silicon Valley, this requires targeting particular occupations or industry sectors, maintaining communication with workers over an extended period, building strong relationships with employers, deliberately focusing on workers' long-term needs, and providing both formal training and informal on-the-job learning opportunities over extended periods of time. The major benefit for the VET provider from closer ties with specific groups of enterprises are good prospects for job placement for graduates of their programs.

Conclusion

The particular focus of this chapter has been on the role of the VET sector in economies with strong track records in innovation. The examples of Finland and Singapore in particular have shown the important role human capital plays as part of a national innovation system.

The key ingredients of the innovation process identified from the case studies are the important role of government in providing a supporting environment and a broad and deep skills pool with a combination of hard and soft skills. The case studies also provide information about new, more responsive skills formation arrangements, including the importance of focusing on international benchmarks, and closer ties to the workplace. The role of vocational education and training providers as intermediaries in industry or regional clusters is noted.

The lesson for Australia is not only to expand its efforts to develop an effective pool of trained innovators, such as trained scientists and engineers; attention also has to be paid to the types of skills required at the sub-degree level. Consideration also needs to be given to how best to impart entrepreneurial skills at all levels of the education process. Vocational education and training providers have a central role in the process of lifting

Australia's capacity to compete with countries placing a major national emphasis on innovation.

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How businesses innovate today and what that means for the workforce

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This chapter examines the evolving workplace in light of business demands for it to be innovative. Innovation is defined as 'doing something new or differently that adds value or is useful'. While change and innovation have been constants in business, there are significant differences between the past and present (and future) in both the pace of change and its unpredictability. To manage, and indeed profit from this new environment, companies and whole economies must bring into alignment their culture (or mindset), their systems and processes, and their resources.

Current and future conditions demand a new, more open and trusting workplace where diversity and creativity are encouraged and recognised for their ongoing contribution to innovation. Valued employees, at all levels, from management to the shop floor, will not only be those with 'hard' technical skills, but also the 'softer' social skills required for decision-making and managing relationships. Furthermore, given the speed of technological change, companies will require a workforce capable of adapting and integrating new technologies within existing processes and systems, and conversely, adapting existing business systems to accommodate emerging technologies.

This will require members of a workforce to be confident in their capacity to reach beyond the comfort zone of personal experience, as well as beyond the internal boundaries of their job description. It will require an education system that recognises the inherent creative capacity of the individual, and which can build, and indeed restore, the environment of trust needed for individuals to express their creativity.

Defining innovation

IT HAS BEEN SAID that innovation is the servant of many masters—everybody has an opinion and a definition of what 'innovation' means, and when attempting to define it, it's helpful to take a wide view of innovation, treating

it as 'a whole of organisation' issue.[1] It's not just science and technology, or research and development, although these are obviously critical components of a modern innovative economy; innovation is doing something new or differently which adds value or is useful.

This definition provides an insight into the key elements of innovation. Not all innovations are necessarily new ideas, but can in fact be old ideas applied differently. Take for example, the internet technology, which began by connecting computer networks at several universities and research laboratories in the United States, and which is now being applied to the home delivery of food, online stock trading, banking and to hundreds of other areas in life.

Important to defining the concept of innovation is the notion of 'doing'. Ideas are the seeds from which innovation grows, but unless an idea can be validated and applied, or a concept proven and executed, they are just ideas or concepts, as good or as bad as they may be. The simple patenting of a technology does not necessarily make it an innovation, particularly if it is never applied or commercialised.

Equally, just because something is new or different, it is not necessarily an innovation. Unless the technology, process, service or product adds value to a business operation or is useful to the community in which it is applied, it is not an innovation. Further, what might be regarded as an innovation in one context or community, may also be regarded as of little value or use in another.

Thus, doing something new or differently that adds value or is useful becomes the foundation upon which innovations are built.

Change is constant

How often have we heard the maxim that change is constant—this is true and has always been so. The difference today is that change is faster, moving at an exponential rate across all fields of human endeavour.

So too, businesses have always had to innovate. Today however, corporate innovation must take place as part of a globalised, more 'open' system. It would seem that this shift towards what we might describe as 'open innovation' began shortly after the Second World War, and really took hold with the arrival of the world wide web.

The web has accelerated the flow of information and knowledge across the globe, inside companies, between companies and across economies. Coinciding

[1] In this context, a 'whole of organisation' issue refers to the fact that innovation is not simply about new technology, products or services; it also refers to corporate culture and business models, including ways of financing, getting products to market, dealing with customers, and how the business deals with new ideas concerning any of these issues.

with this were three other significant factors—the globalisation of financial markets, the movement of capital, especially the rise of venture capital, and the increasing mobility of a highly educated workforce. These three phenomena have stimulated a major shift in the way in which not only companies, but entire economies, need to interrelate.

To help understand the impact of all of this on how companies innovate, and the consequences for the workforce, it is perhaps useful to think in terms of the three fundamentals for business success. For any company or economy to be successful, it must bring into alignment its culture (or mindset), its systems and processes, and its resources.

It is no coincidence that the most successful economies or corporations have a cohesive, dominant internal culture or mindset. This has always been so. How an economy or a company organises itself (its systems and processes) in terms of its creation, production and distribution of goods and services is fundamental to its success. The third fundamental for business success is a company's resources in terms of intellectual property, financial capital and physical assets, such as new technology.

Mindset (culture)

The culture of an innovative or smart company today must be increasingly based on openness, trust and diversity—openness, because no company can stand alone in a global economy. Even major corporations such as IBM and Proctor & Gamble are simply not 'smart' enough or sufficiently resourced to do it alone. As recently as 1999, Proctor & Gamble recognised this when the company appointed a director for external innovation.

At a shop floor level, this requires workers to be open to new ideas and to be willing to accept external input. This need for openness brings with it an increasing reliance on trust. To share ideas, to accept input from others requires a willingness to trust. We all know of the experience of the worker who shared an idea for a business improvement or innovation with a supervisor or colleague, only to have it plagiarised or stolen. There will simply be no place for this type of behaviour in the new workplace. As new processes and systems for innovation are adopted in the workplace, those guilty of this type of behaviour will be discredited. As Henry Chesbrough (2003) says in *Open innovation: The new imperative for creating and profiling from technology*, companies must, 'Share and be prepared to learn'.

Traditionally, we would associate the power of organisational culture with notions of homogeneity or 'sameness'. In this context, 'diversity' has been seen to be little more than a compliance issue or at best the imposition of external 'political correctness'. Today's innovative companies, however, see diversity as a powerful business tool. Increasingly, companies are coming to recognise the value that different perspectives can bring to the creation of new products and

services, solving problems and the generation of new opportunities. Smart managers now recognise that the last person they want to employ is a clone. Here the emphasis shifts from a focus on ethnic, religious and sexual diversity to intellectual diversity.

IBM's Diversity Mission Statement provides an insight to this shift:

> *IBM values diversity and recognises the need to capitalise on the skills, opinions and talents of all segments of its workforce. Valuing diversity in IBM uncovers new perspectives, taps different knowledge and experience, and generates ideas, suggestions and methods not otherwise considered.*
>
> *We invest in our people to develop their strengths, giving us an outstanding workforce in the industry—a workforce where differences are expected, encouraged and respected.* (IBM 2003)

In 2002, the Department of Immigration and Multicultural and Indigenous Affairs hosted a series of business consultations around Australia in partnership with Drake (the human resources company) the Australian Industry InnovationXchange Network, the Australian Human Resources Institute and 64 other organisations, to explore the relevance and business benefits of Australia's language and cultural diversity. It is clear that diversity is being increasingly seen as much more than 'simply recognising difference'.

The resulting report, *Productive diversity: Investing in your organisation and Australia's future*, found that businesses see diversity as essentially an issue of skills, that is:

> *… it is about businesses being able to draw new skills to the organisation or make better use of the skills they already have. The skills and talents to be found in a diverse workforce … can be of vital importance to business.*
>
> (Department of Immigration and Multicultural and Indigenous Affairs 2003, p.15)

The report concluded that:

> *Diversity can provide significant benefits to business through creating workplaces that treat everyone with respect, which encourage new ideas and perspectives and where workers feel valued and appreciated for the unique contributions they can offer.*
>
> (Department of Immigration and Multicultural and Indigenous Affairs 2003, p.5)

Individual creativity and innovation are important skills of a diverse workforce and can be used by smart companies to extend traditional business boundaries. As one participant in the consultations observed:

> *Using diverse work teams broadens the way we see things. It increases the scope of possibilities and allows our people to come up with more creative business solutions.*
>
> (Department of Immigration and Multicultural and Indigenous Affairs 2003, p.8)

The job advice provided by many parents 20 years ago would have been along the lines of, 'find a job that's safe and secure, you can't go wrong with a trade. Be reliable and make sure you fit in'. Ensuring success in the workplace today and in the future will require a very different mindset. Being able to 'fit in' is increasingly less important than an employee's ability to understand and contribute to the goals of the business through creative engagement with their work.

This imperative for openness, trust and diversity within a workforce demands that our vocational education and training (VET) system provides a learning environment which reinforces and develops these qualities.

Capabilities: Systems and processes

Some would say that the invention of the motor car has changed the world. It is perhaps more accurate to say that Henry Ford's introduction of mass production changed the world. The issue here is that the success of an economy or a company is in large part determined by its ability to put in place systems, processes or business models capable of effectively and efficiently converting its resources into economic output.

The shift from closed to open economies and from closed industrial 'silos' to more integrated, horizontal systems, brings with it important implications for the VET sector and the future of the workforce. The days when a skilled tradesperson could enjoy a long career inside an isolated workshop are rapidly passing. As organisational structures become increasingly flat and integrated, there is a growing need to push decision-making further down the management chain, closer to the 'coalface'. There is also an attendant need for lower-level managers to be able to connect externally, either to other units within their company, or directly with customers and clients.

An obvious implication of all this is that tomorrow's skilled tradesperson will need to have a higher level of decision-making capability and relationship skills. Our vocational education and training system will need to provide for a workforce which not only possesses the hard technical skills, but the 'softer' social skills required for decision-making and managing relationships.

As innovative companies re-organise their processes and systems to get closer to the market and their customers, there will be greater pressure on staff at all levels to better relate to their clients. Some call it 'mass customisation', while others talk about 'listening to the customer'. Whatever the terminology, many more employees at all levels will carry the company's reputation with them and represent the company to clients.

A consequence of companies moving closer to the consumer is the need for a competent, technically skilled workforce which understands business. A skilled tradesperson who understands and appreciates the impact their technical

capabilities can have on a company's business in the fullest sense, will be far more valuable than a technician who can only see the technology. So too, the manager or supervisor who can appreciate the impact of technology on business opportunity will be far more valuable than the administrator who is only maintaining schedules.

Today companies must innovate within an ecosystem that is far more complex than in the past. For example, it is often said that companies themselves no longer compete, but that supply chains compete. The relative simplicity of the 'virtuous cycle', whereby new ideas were generated within a company, developed and taken to market using the company's own resources, is giving way to an array of complex new business models. While some companies increasingly rely on the licensing of their intellectual property, others jockey to form strategically important alliances with suppliers, manufacturers and distributors around the globe.

Large multinational corporations in particular, are reorganising how they do business. Previously a company like Nestlé or Electrolux may have had multiple production sites for single products scattered around the globe to service local markets, but today these have been consolidated and located in single sites to maximise economies of scale.

Michael Garrett, Executive Vice-President of Nestlé recently shared his thoughts on innovation in large companies and the need for innovation across the entire business. A Nestlé initiative which began some three years ago reduced the number of external suppliers from a reported 600 000 to 167 000, and as Michael Garrett observed:

> *Despite having the number one or number two brand in most categories around the world, we have learned that listening and responding to consumers means developing new ways and new structures. For example, we no longer have sales managers. Given the size and complexity of the business we do with our retailers, we now have business managers. Their job is to manage the complete relationship in a way that gets the best business outcome for our customer and for us.*
>
> (Garrett 2003, p28)

As a consequence of these large-scale business innovations, workers not only need to be able to operate in a more complex organisational structure, they also need to be more agile and willing to reskill. Workers have always had to go to where the jobs are; the difference now is that the types of jobs are changing at an ever-increasing pace.

Twenty years ago an electrician may reasonably have been expected to encourage his son or (if he was enlightened, his daughter) to pursue a career similar to his own. Today however, a parent simply cannot imagine what types of jobs will be available in 20 years time. Will there be such a thing as a 'nanoelectrician'?

While the VET system faces a challenge in being able to predict and identify emerging employment trends and skill needs in order to build lifelong training

programs, it is just possible that there is an even bigger challenge looming. The way we do business in 20 years may, in fact, be nothing like the way we do business today. Companies are becoming increasingly aware that, not only must they change the way they organise themselves, but they also need to look for entirely new legal and business structures. It is just possible that the current corporate structures which have evolved to serve the industrial economy may themselves evolve over time as we search for new ways to do business in a global economy.

Resources

Resources, in this context, may easily be defined as the available financial capital, human capital and physical assets. The quantum of resources available is, to a large part, determined by the financial capital available to a particular company at any given time. Companies have for a long time recognised their workforce as an important resource (although I suspect in the early days of the Industrial Revolution this was often not the case) while balancing the allocation of limited capital between the development of a skilled workforce and the maintenance of efficient production and distribution assets. The emergence of a knowledge economy suggests that companies will increasingly need to place greater emphasis on the allocation of capital resources to their workforce.

In the past, the role of an employee has generally been one of service to the internal company machine—not only in terms of plant, but importantly to the processes and structure of the system. While yesterday's worker (and in some cases today's worker) has been required to have the skill necessary to operate particular machinery or to perform a particular function, tomorrow's worker will not only be required to have these skills, but will, more importantly, be expected to contribute to the company's ongoing innovation process.

In the future, smart companies will invest more heavily in their human capital. They will seek out and invest in employees who can not only operate their business, but who can expand the business. As the capacity of a worker to contribute to the intellectual capital of a company becomes increasingly important, so too will vocational education and training programs which develop these new skills.

Companies will continue to allocate their available capital to physical assets, particularly new technologies, but unlike in the past, these technologies will increasingly be 'enablers'. Under the old system, the company may invest heavily in new equipment and technology because it fits existing systems and processes. Subsequently the company will require its workforce to become skilled, adopt skills or be retrained to maximise return on investment and production output. It is possible now to imagine a future where the emphasis is reversed.

In a knowledge economy, investment in new equipment and technology will obviously remain a priority; however, given the speed of technological change

and the risks inherent in investing in such technologies, companies will require a workforce capable of adapting and integrating these technologies within the company's existing processes and systems, and conversely, adapting existing business systems to accommodate emerging technologies.

Here the notion of creativity is important. Many recognise, for example, the vital role of creative design in underpinning consumer product innovations, but creativity in a wider sense is an absolutely essential ingredient of a successful business culture. Creative new business procedures, an open-minded attitude to new ideas, to collaboration and to the sharing of knowledge, the acceptance, and more importantly, an enthusiasm for the power of differences of all types amongst staff, are all elements of a creative and innovative culture.

In summary, companies will be increasingly concerned to invest more heavily in their human capital resources, but in turn, will demand significantly higher levels of base competencies.

What does all this mean for the workforce?

While the vocational education system may be required to train the nanoelectricians of the future, or develop computer courses applicable to emerging industries, such as biotechnology, the real challenge will be to create a workforce with the basic personal skills which will be demanded in a world where the only constants are change and the pursuit of competitive advantage through innovation.

This will require members of a workforce to be confident in their capacity to reach beyond the comfort zone of personal experience, and beyond the internal boundaries of their job description. And it will require an education system which recognises the inherent creative capacity of the individual and which can build, and indeed restore, the environment of trust needed for indiviudals to express their creativity.

Here I might add a word of caution on the obsession of 'team building'. While there can be no doubting the positive potential to flow from team learning and team-working approaches with good leadership, we need to be cautious not to allow the notion of team work to simply become another form of consensus-driven peer pressure. A successful team demands that its individual members bring their full capabilities and individual skills to the game.

Does all this mean that the vocational education system should introduce a basic innovation training skills program? Many would be familiar with the ongoing debate over whether or not it is possible to teach innovation. While there will be value in programs to train people in some of the processes, such as how to generate and capture ideas, how to collaborate with each other and how to represent their ideas to others, people's ability to perform these processes will ultimately be determined by broader factors such as individual confidence and creativity.

There will be those who will argue that this is not the role of a VET system and that, at best, responsibility for such training belongs with the primary and secondary education systems or with the wider community. I would urge that this is not so. The role of the VET system is to contribute to the education of a skilled workforce—and a fundamental skill in a knowledge economy is the capacity to think and act creatively and openly with confidence.

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Innovation, economic growth and vocational education and training

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This chapter explores a number of areas where the vocational education and training (VET) sector might make contributions to the future growth of the Australian economy through enhancement of the human capital[1] support infrastructure. The chapter discusses some key human capital challenges to be faced in ensuring that the economy maximises its innovation and economic growth opportunities. In this context it also briefly reviews some of the changes in the labour market expected to occur in the coming decades, with a view to highlighting key areas where innovative education and training initiatives might assist in promoting higher economic growth than might otherwise eventuate. The chapter does not look at issues internal to the VET system in any detail, instead confining observations about the internal working of the VET system to arguments about the need for frameworks that will encourage the system to be flexible, innovative and responsive to signals about future skill needs.

Introduction

IN RECENT YEARS, the so-called 'new growth theory' has highlighted how increases in human capital can contribute to economic growth. Greater investment in training can stimulate growth by increasing labour productivity through the provision of greater skill levels and by giving employees the skills needed to complement new technologies. It can also contribute to growth through so called 'positive externalities', such as when knowledge spills over to

[1] In human capital theory, workers are defined as vehicles for the economic progress of the nation.

others who have not undertaken training. Other benefits include greater levels of social cohesion and tolerance which underpins social capital.[2]

A recent Organisation for Economic Co-operation and Development (OECD) study examining the drivers of economic growth in OECD countries during the 1990s highlighted the importance of investment in human capital. According to this report, the availability of a large pool of qualified personnel aided growth, while shortages of skilled labour acted as a constraint (OECD 2001, p.55). In Australia, the link between education and innovation, and economic growth has been examined by Dowrick (2002, p.21). He estimated that greater investment in the Australian 'knowledge economy', through education, training and innovation, has the potential to raise the annual rate of economic growth by approximately half a percentage point.

It is important to note that it is not just those aspects of education that better equip the community with the skills and knowledge base which stimulate ideas formation and the associated innovations vital to economic growth. Also of critical importance is a workforce that is positively disposed to change, and which can be quickly re-skilled in order to effectively implement new innovations. This is particularly important for major innovations of a technological nature, such as those associated with information and communication technologies.

Having established that training is important for economic growth, it must also be recognised that changes in the labour market can affect the way training contributes to this growth. In the coming decades, significant changes are expected in both the supply of and demand for labour. Therefore, in addition to examining the relationship between innovation, economic growth and human capital on a broad scale, this chapter also looks at some major demographic-based changes expected to take place in the labour market, and how innovations within the vocational education and training and other related sectors of the economy will be vital to enable effective and rapid response to these changes.

The Australian Government's 'Intergenerational report' (Australian Government 2002) provides a useful framework for considering the impact of demographic-based change on the labour market and for speculating on the implications of these changes for the VET system. Inherent to the Australian VET sector are features that provide it with the capacity to respond to impending changes in the labour market. This system has the capacity to tailor its products in a way that focuses more closely on particular problem areas than is possible in other sectors of education and training. For example, the VET sector is able to provide courses to people of almost any age and level of

[2] Social capital is defined as the cumulative benefit accruing to individuals and communities as a result of their engagement in community and civic activities.

educational attainment, while also having the flexibility to do so in innovative ways which meet the needs of these people. This flexibility ensures that it is ideally placed to play a central role in meeting many of the challenges that seem likely to arise from future changes in the labour market. Having said that, it is almost certainly the case that a successful outcome will depend on a creative and coordinated response from all relevant sectors of the economy, not just the VET sector itself.

This chapter discusses the question of innovation and the challenges facing the education and training sector in Australia from two perspectives. Discussed first of all is the role of innovation as a key driver of economic growth, and the important role education and training has in providing the necessary platform to enable innovation to take place, and for its effective implementation within the economy. A number of developing challenges within the labour force, and the consequent need for innovative initiatives within the education and workforce support infrastructure to address these impending challenges are also discussed.

Innovation and economic growth

There are three primary sources of economic growth. The first two arise from growth in the primary inputs of capital and labour—increases in capital and labour inputs lead to increases in gross domestic product as shown in figure 1. With relatively free and efficient global capital markets, there is no immediate constraint on increasing the level of capital stock in a small economy like that of Australia. However, there is a significant constraint on achieving more than relatively small and gradual sustained increases in aggregate labour input as measured by hours worked.

The third source of economic growth is multifactor productivity. Multifactor productivity growth is defined as the growth in 'value added' which is not explained by contemporaneous growth in capital and labour. Multifactor productivity growth can arise from a number of sources including:

- improvements in the economy's operating environment; for example, government policies which facilitate greater competition and trade
- adopting best-practice management and business production processes, many of which are imported from overseas
- the discovery and implementation of new production technologies and processes.

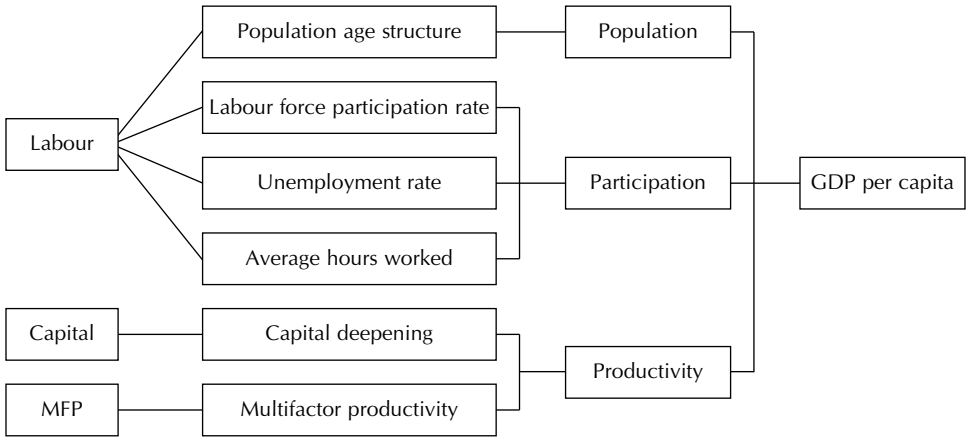
In order to achieve higher output levels or quality using the same amounts of primary inputs, something has to be done differently. This could be:

- better economic policies

- ❖ an improvement in the method of production; for example, the development of more efficient plant and equipment or the discovery and implementation of more efficient ways of using new capital, embodying technological advances
- ❖ better skills embodied within individual units of labour.

That is, innovation of one sort or another has to occur.

Figure 1: The components of gross domestic product per capita growth



Note: 'Productivity' refers here to labour productivity.
Source: Adapted from Department of the Treasury (2003, p.97)

In the past, the term 'innovation' has been most commonly identified exclusively with scientifically based discoveries which led to new production technologies and products. While this most certainly constitutes innovation, the term 'innovation' is now generally interpreted in a much wider context.

The notion of innovation encompasses the entire process, which ultimately results in the provision of new goods and services, and/or the provision of the same goods and services but in a more efficient way. It includes the processes whereby new ideas are generated, proved and adjusted through prototype work, integrated with existing products and processes, tested in markets, and fully commercialised. It also includes the complex feedbacks of information, and additional ideas generated during the process itself. That is, it is typically a complex non-linear process.

It is important to emphasise that innovation also includes the discovery and application of better management techniques and business practices, and new and improved ways of using and adapting existing production technologies to more effectively capitalise on their economic potential.

Innovation is thus the major driver of multifactor productivity growth, which itself is fundamental to economic growth. Estimates indicate that

multifactor productivity growth has generally accounted for between 30 and 40% of gross domestic product growth in Australia's market sector (Parham, Roberts & Sun 2001). Table 1 provides a breakdown of the contribution of capital, hours worked and multifactor productivity growth to market sector growth over the 35-year period, 1964–65 to 1999–00, and over the most recent 10 years of that period.

Table 1: Contributions to Australia's output growth in the market sector

Component	Contribution	
	1964–65 to 1999–00 % per year	1989–91 to 1999–00 % per year
Capital	1.8	1.7
Labour	0.6	0.3
MFP	1.1	1.4
Output growth	3.4	3.4
MFP as % of output	32.0	41.0

Source: Parham, Roberts and Sun (2001)

With multifactor productivity growth accounting for almost half of gross domestic product growth, and innovation being so critical to multifactor productivity growth, it is clear that a general environment conducive to the fundamental drivers of innovation is vital to Australia's future wellbeing.

In order to pursue this analysis further, we need to look behind the notion of innovation to reveal its key drivers. The key drivers are many and varied but include: *competition*, which drives entrepreneurs to seek out competitive advantage through innovation; appropriate *intellectual property policy*, which allows for private appropriation of returns to innovation; and an *innovation culture*, supported by a critical mass of *education and knowledge*, upon which the generation of new ideas and the realisation of their associated potential through effective commercialisation can be achieved. It is in the development and maintenance of an innovation culture, and in the enhancement of the education and knowledge platform so critical to innovation, that the VET sector has a vital role to play.

Human capital and innovation

What then are the critical human capital factors necessary to support an effective innovation culture, and what is the role for the VET sector in assisting in their realisation?

The most obvious innovation-related human capital issue, and the one which receives the most attention, relates to the provision of sufficient numbers of technological specialists, such as scientists and engineers. While this is indeed

an area of critical importance, especially in relation to what might be termed 'technological innovation', there are, as discussed above, many vital aspects to the innovation process. For new ideas and discoveries to confer broad benefits on society, they have to be appropriately designed and presented to the commercial marketplace, and, generally speaking, scientists and engineers are not the people to undertake this role. In addition, business management and production process innovations are also not commonly the realm of such specialists.

It is arguable that a major component, although certainly not the entirety of the creative aspects of innovation, is likely to arise within that part of the workforce having its human capital largely developed through the higher education system. That said, there will be many micro and small business innovations that are not derived from, or dependent upon, higher education. For example, many small businesses are owned and operated by people who have developed their human capital outside the higher education system, and whether it be a trade-related business, a café or restaurant, or any other small business, innovation at some level will be critical to the ongoing success of the business.

As competition becomes more intense, entrepreneurs in particular need to become aware of the importance of innovation, and of the need to invest time, effort and resources into enhancing their 'innovation capital'. The VET sector provides a vehicle for those needing to enhance their understanding of the innovation process and their innovation-related skills.

Another key human capital challenge associated with major innovations, particularly those of a technological nature, arises not in the development of innovations per se, but rather in the successful implementation or application of innovations. The quintessential example of this is to be found in the adoption and implementation of information and communication technologies.

In the context of just one manifestation of this, the successful dissemination and implementation of the desktop computer, together with the associated user-friendly software and technological innovations such as the internet, have required very significant complementary investments in human capital on a universal front. A rudimentary understanding of how to use a desktop computer and the most common software applications is now a fundamental requirement in nearly all service-based industries, while much more sophisticated information and communication technology skills are required in a growing number of careers. Other examples are to be found right across the economy; for example, how to use computer-based technologies in diagnostic motor mechanical work. Technology-using skills such as these are learned either in or directly through the workplace, in schools or in the VET sector.

The importance of the appropriate complementary environment for innovation, and hence productivity and economic growth, is now well documented in the economic literature, most particularly in relation to major

innovations such as those associated with information and communication technology (see for example Bresnahan, Brynjolfson & Hitt 2002, pp.339–76).

Despite this clear link between information and communication technology skills and productivity, the OECD has found that the large increase in labour productivity in Australia over the 1990s was achieved without any measurable contribution from overall 'enhancements to human capital', that is, skill upgrading of the workforce. This contrasts with the situation in some European countries, most notably the United Kingdom, Finland, Italy and France, where skill upgrading was responsible for up to one-third of the labour productivity improvement (OECD 2003, p.38).

These results for Australia have been confirmed by the Productivity Commission, which found that increased skills in the workforce did not have a major effect on Australia's 1990s productivity surge (Barnes & Kennard 2002, p.xix). Although the measurement of changes in human capital is at an early stage of development in Australia, the results as they stand do suggest the possibility of considerable scope for additional economic gains from enhancement of Australia's human capital through additional training.

To summarise, the sections above have identified two distinct human capital aspects of innovation, the first being the creative human capital necessary to discover or identify potential innovations and to drive their adoption and implementation. The second aspect is concerned with enhanced complementary human capital necessary for successful adoption and implementation of the innovation. The VET sector has a role to play in supporting the development of both types of human capital enhancement.

Responding to the changing human capital challenge

The rate of introduction of new technologies, together with a much more dynamic and innovative global business environment means that the skill sets required of the broader labour force are growing and changing with ever-greater rapidity. This in turn means that an increasing number of the skills learned at school and early in one's career become obsolete, or at least in some way insufficient for the new demands arising from the introduction of new technologies and innovations.

Information and communication technologies and their various applications once more provide a good example. While children at school are now all exposed to the fundamentals of this technology and its use, there is a large section of the workforce which either has no such skills or has had to acquire these skills since leaving school. Thus, as technologies and innovations which are implemented within the workplace are developed, the need to skill-up the existing workforce arises. This is particularly the case where the innovation is becoming an integral part of the production process, and where the associated skills had not commonly been part of the school curriculum.

Another human capital challenge arising from the increasing rate of innovation in the economy derives from businesses' need for a workforce which readily accepts, and is able to respond quickly to, the changing workplace demands being driven by these innovations. Increased flexibility in this respect reduces the adjustment costs faced by the economy in implementing new technologies and other innovations, and brings forward the benefits that such innovations offer, adding to the rate of productivity and economic growth in the economy.

It is important to recognise that these issues are not simply an education and training supply-side problem. Resolution of the challenge requires the efficient functioning of a cooperative network which includes the VET sector, the business sector, and institutional components of the labour force, such as the trade unions.

The demands on and interactions among the members of this coalition are complex and can be expected to become even more so. For example, the client base for vocational education and training is, in a sense, bilateral. On the one hand, business is the key client as it seeks the provision of certain labour force skills, and on the other, it is the individuals who make up the existing and prospective workforce which forms the client base. The requirement for ongoing clear communication of the needs of the demand side of the 'equation' is obvious, but may not always be satisfied. Moreover, the views and interpretation of detailed aspects of these demand-side needs as held by employers, and employees and their representatives, may well, from time to time, not be in complete harmony.

It also needs to be recognised that the challenges faced by the workforce in responding to the changing demands in the workplace are not homogenous. Some parts of the workforce may already be experienced in handling the introduction of disruptive technologies[3], while others may have been employed in an industry using relatively long-term stable production technology and processes, and having little or no experience in coping with disruptive change. The latter group can be expected to face more significant challenges in dealing with these changes, and will, in all probability, need greater support and understanding from the VET sector and employers.

Faced with complex and rapidly changing client requirements, the VET system needs to be flexible and innovative, both in helping to ensure that the evolving needs of its clients are communicated to and disseminated within the sector, and also in addressing those needs through the innovative design and delivery of training programs.

There are many arms to an effective system of support for a more responsive, better skilled and more flexible workforce. The obvious key players

[3] The term 'disruptive technology' was coined by Clayton M Christensen (1997) to describe a new, low-cost, often simpler technology which displaces an existing sustaining technology.

in such a network include the existing employed workforce, the existing unemployed portion of the workforce, employers, and the VET sector. Other players who may be less immediate in some sense, but who are also critical to the dynamic efficiency of such a network, include schools, cohorts of impending school leavers, the higher education system, and parents. All of these agents have a role to play, but can only do so effectively if supported by a well-coordinated network with an efficient and comprehensive information and communication system.

Contributing to economic growth

As noted earlier, economic growth is derived from growth in the stock of capital, growth in labour inputs, and multifactor productivity growth. While innovation is the key to multifactor productivity growth, population growth and labour force participation are the keys to growth in labour input (human capital quality enhancement aside). Declining fertility rates, and the ageing and impending retirement of the so-called 'baby boomer' generation raise the prospect of lower population growth and a future reduction in the participation rate. This will ultimately detract from growth in future labour input, and consequently also from economic growth.

The 'Intergenerational report' examined projections of the possible impacts of demographic change over coming decades in a scenario involving no changes to government policy (Australian Government 2002). It found that under these conditions economic growth would be likely to slow considerably. This report also examined the reasons for this slowdown by looking at the labour market supply-side components of gross domestic product per capita—population, participation and (labour) productivity—and the factors affecting these components (see figure 1).

The 'Intergenerational report' projections suggest that gross domestic product growth over the next four decades will average only 2.25%, 1.5 percentage points lower than the average for the previous four decades. Population growth is expected to make a significantly lower contribution to gross domestic product growth, whereas labour productivity will be the key driver (Henry 2002). This reinforces the claims made in previous sections, given that labour productivity growth is the sum of capital deepening (the increase in the capital/labour ratio) and multifactor productivity growth, which depends so critically on innovation. Participation is expected to have a much greater negative impact (Henry 2002).

While there is little that can be done to reverse the decline in population growth, it is arguable that, by better targeting training investment, participation could be increased with a positive impact on economic growth. Of course, it needs to be recognised that issues impacting on the supply of labour are only part of the bigger picture, which includes the employers on the demand side.

Employers need to play an active part in establishing and maintaining communication networks with key parts of the labour market, the education and training sectors, and other crucial areas of support infrastructure. For example, those who recognise new technologies or developments that will impact on potential economic growth need to communicate the anticipated labour force requirements in order to ensure that the VET and other sectors are directing their resources to the emerging human capital needs of business. In addition, government policies need to place greater emphasis in the community on lifelong learning and active participation in the workforce and the community. However, this chapter will restrict its consideration to supply-side issues.

Participation

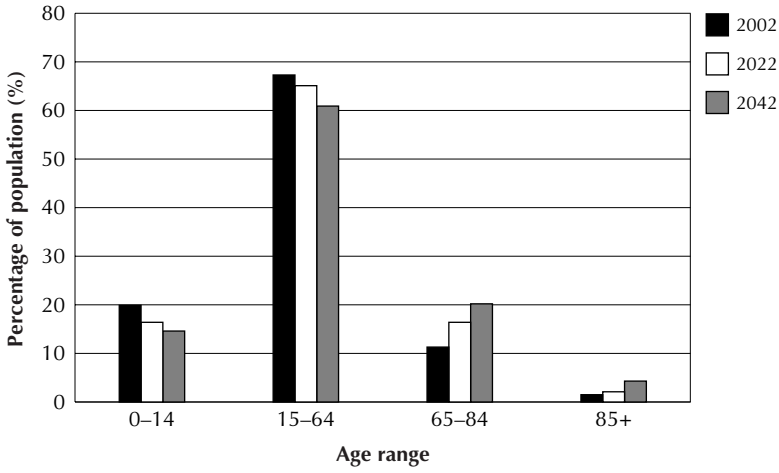
The major components of participation, as shown in figure 1, are the labour force participation rate (the proportion of the population over 15 years old who is either employed or actively seeking employment), the unemployment rate, and average hours worked. The 'Intergenerational report' estimates that participation will have a negative impact on gross domestic product growth over the next four decades, reducing average annual gross domestic product growth by 0.38 percentage points (Henry 2002). Declining participation rates have been attributed to a number of factors, including an inflexible labour market contributing to mismatched skills, the retirement of older workers, and the preference by some welfare recipients for welfare payments instead of uncertain applications for work (Department of Treasury 2002, pp.104–5). Furthermore, punitive effective marginal tax rates for those moving into the workforce or increasing their current hours of work do not encourage greater participation.

The social and economic costs associated with reductions in labour force participation include lost productive capacity and depreciation of the skills base. For individuals no longer participating in the workforce, it can mean reduced self-confidence and an overall reduction in the individual's contribution to society. Two factors that can potentially slow the impact of these costs are encouraging older workers to defer retirement or encouraging them to return to the workforce, and increasing the labour force participation of those of working age.

Increasing participation of those of working age

The 'Intergenerational report' projections in figure 2 show a decline in the population share of the 0 to 14 and 15 to 64 (the working age) cohorts in 2022 and 2042, and an increase in the proportion of the population in the 65 to 84 and 85+ cohorts. While the projection is that the working-age population will rise in absolute terms by 14% over the next two decades, this will be overshadowed by a 50% absolute rise in the 55 to 64-year-old cohort over the same period (Australian Government 2002).

Figure 2: Population projections, 2022 and 2042



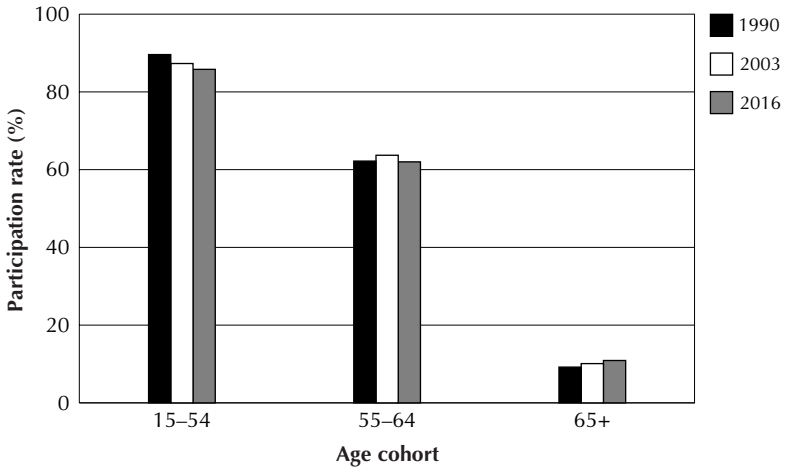
Source: Australian Government (2002, p.22)

These impending developments, together with the improving health and longevity of older members of society, suggest that past notions of an appropriate retirement age might need to be reviewed.

Figures 3 and 4 present past, present, and projected labour force participation rates for males and females. These projections are based on an assumption that the present trends in participation continue. The male participation rate shows a downward trend in the 15 to 54-age cohort and little movement in the 55 to 64-age cohort. Male labour force participation declines most markedly beyond the age of 40, apparently as a result of difficulties associated with middle-aged men finding employment after being out of work for some time (Ball 2003, p.3). The female population displays upwards trends in participation for all cohorts, most significantly in the 55 to 64-age group, although female participation rates are still well below those of males.

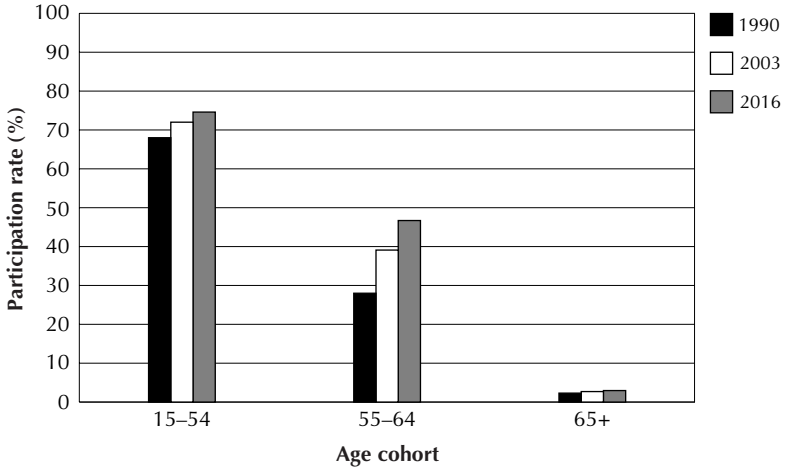
These trends suggest that there may be some scope, especially as future demographic pressures begin to impact on labour supply, for increased male participation by those of working age, particularly men over 40, as well as higher levels of female participation at all ages. But responding to these opportunities efficiently will mean appropriately gearing up the necessary training in advance of the emerging shortage, and ensuring that training is focused on the specific skills associated with the developing labour shortage.

Figure 3: Male participation rate



Source: ABS (1999)

Figure 4: Female participation rate



Source: ABS (1999)

Why the VET sector needs to be more innovative

The VET system has the potential not only to support a more flexible workforce, but also to help those not in the formal labour market to participate in the workforce, and older workers to stay in the workforce for considerably longer than in the past. Training need not necessarily be directly related to existing occupations. New skills have the potential to enable those workers nearing retirement age or under-employed in 'casual' or 'part-time' work, as well as younger people not yet in the workforce, to undertake new work opportunities.

The VET sector needs to look towards the 'informal' labour market; for example, there has been a large growth in microbusinesses in the last five years (Australian Government 2002), and so those who might wish to retire, or who are not in the formal labour market, could be trained to start their own businesses. The VET sector needs more innovative marketing and ways of making contact with potential clients who would benefit from the acquisition of business skills in their self-employment ventures.

Entrepreneurship training for older workers, or those who have retired, could, of course, be extended to younger workers and the unemployed seeking to explore opportunities provided through small business creation.

Such training could benefit from innovative approaches designed to minimise the incidence of failure of new entrepreneurial ventures. These might include, for example, experimenting with some form of small business joint ventures between vocational education and training and retired entrepreneurs to provide a real hands-on component to the training, complementary to the more traditional components, such as bookkeeping and other theoretical aspects of running a small business. Such joint ventures could even provide the basis for continuity of association with the VET sector and improved network opportunities among participants following their hands-on entrepreneurial experience and subsequent graduation. This has the potential to further reduce the incidence of small business failure.

Given the projected demographic change, it is all the more important that the participation rates of younger people be significantly higher than today. As education levels are highly correlated with employment prospects and participation, it is critical that future cohorts entering the workforce be appropriately educated.

In this regard, studies by the Centre for Community Child Health (Waters, Goldfield & Hopkins 2002, p.64) and The Smith Family (The Smith Family 2003, p.56) suggest that higher education levels among parents flow on to higher educational and academic outcomes for their children. Therefore it may be an important strategy to encourage parents with low-level education attainment to further their education through appropriately targeted vocational education and training in order to help improve the participation prospects of future cohorts. An initiative such as this could be addressed through policy initiatives which support innovative marketing schemes, or other more direct incentive mechanisms.

The unique features of vocational education and training—its ability to provide all types of training for people of all ages and levels of educational achievement, and its ability to provide short courses and specially designed courses to meet specific needs—differentiates this sector from other education and training sectors. These unique features provide VET with the ability to take advantage of opportunities to trial new initiatives which might positively address future participation concerns.

Conclusions

Innovation is the process by which new ideas and discoveries are made and turned into valuable new goods and services, or more efficient ways of producing the same goods and services. Innovation encompasses the entire complex process from ideas through to the realisation of additional value to the economy. It is characterised by feedback loops and other complex interactions with the existing economic and social infrastructure, and it covers technological innovation (typically based in scientific and related research), product innovation (both goods and services), and process innovation.

Innovation is also the key driver of productivity growth. If additional output or enhanced output quality is to be had from the same quantity of capital and labour input, then something has to be done differently—some innovation has to occur.

The important role of knowledge and education in innovation, productivity and economic growth is well established both in theory and in empirical studies. However, it is not just the advanced and specialised knowledge and creative drive of scientists and engineers or business managers and chief executive officers which provide the necessary facilitating medium for effective innovation and productivity growth. To be effective, new processes and technologies need to be efficiently applied in the production process, and this can entail significant investment in the development of complementary human capital. Furthermore, the adoption of new processes and technologies can be quite disruptive, in which case, efficient adoption of such processes and technologies is likely to require a very flexible workforce.

In an ever-competitive global economy, business will constantly be seeking out competitive advantage through innovation. As this culture permeates all aspects of the business sector, existing and new entrepreneurs will need to have well-honed innovation skills, and adequately appreciate the demands which innovation places upon the workforce in general. It is therefore important that the education and training sector is able to provide the support necessary to ensure that new and aspiring entrepreneurs have the appropriate innovation-related skills. In addition, it is equally important for the sector to address the broader workforce re-skilling and flexibility which effective implementation of innovation often requires.

While the VET sector is well placed to play a key role in addressing these demands, it cannot be fully effective alone. To be fully effective will require the close cooperation of employers and other key players to ensure optimal uptake of its services in a timely fashion. For example, employers and others who anticipate certain technological and other developments need to communicate their potential labour force requirements before the need arises.

Looking forward, demographic developments associated with the ageing of the population and declining fertility are likely to bring significant and

sustained pressure to bear on the supply of labour. This will make innovation even more important as a source of economic growth. It will also mean that it will be increasingly important to raise participation rates in the 20 to 65-year age group as well as encouraging retention of older workers beyond typical retirement ages of today.

Increased participation rates are at least partly dependent upon higher levels of education and work-related skills. The myriad influences on education levels and academic achievement include levels of parental education, employer attitudes to training and ageing within the workforce, and the priority given to innovation and entrepreneurship awareness within the school curriculum.

The complex and diverse range of influences on participation rates means that significant progress in this area will require creative and innovative solutions to be sought within a broad coalition of key players, central to which will be the VET sector. A close cooperative network within this coalition, supported by an efficient and effective communication and information system, will be critical to the success of any response to these labour market challenges.

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Innovation agents

Vocational education and training skills in the present and future Australian innovation system

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This chapter[1] identifies innovative industries and firms in Australia, examines the role of vocational education and training (VET)-skilled occupations[2] in the innovation process in these firms, identifies the methods they use to recruit and train for these occupations, and evaluates how effectively VET providers meet the training needs of such firms. These issues were investigated using a broad range of economic and labour market data. A comprehensive literature review and eight case studies of innovation-intensive firms which have a high proportion of VET-skilled occupations in their workforce were also undertaken.

A key finding is that innovation-intensive firms are also training-intensive firms. This association is due largely to the bases of competition between these firms, which is founded on quality, product differentiation, customisation, rapid product cycles and the integration of products and services. These features require a skilled, adaptable and committed workforce. VET-skilled occupations make an important contribution to innovation within these firms as a result of their practical engagement in the design, installation, operation and maintenance of products and processes. The case study firms were very satisfied with technical and further education (TAFE) and other training providers. Finally, VET skills are a necessary, but not sufficient, condition for the growth of innovation-intensive industries.

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[1] A summary of the report, Toner, P, Marceau, J, Hall, R & Considine, G (2004), *Innovation agents: Vocational education and training skills and innovation in Australian industries and firms*, NCVER, Adelaide.

[2] For the purposes of this chapter, VET-skilled occupations are defined as those which have been acquired through an Australian Qualifications Framework (AQF) level of certificate I–IV or diploma, and typically classed under Australian Standard Classification of Occupations (ASCO) Major Group 3, *Associate professionals,* to Major Group 9, *Labourers and related workers*.

Introduction

THIS CHAPTER PROVIDES a selective summary of the report *Innovation agents: Vocational education and training skills and innovation in Australian industries and firms* (Toner et al. 2004). The report examined the relationship between innovative industries and firms and VET providers. The chapter is selective in that it focuses on the main findings and policy implications of the report while briefly covering the literature on the links between vocational education and training and innovation. The report was one of the first such studies on this subject in Australia; this is an important subject as innovation-intensive products and services are a rapidly rising share of world trade, and trade is a rapidly rising share of the output of developed countries. These are products in which quality, reliability, timeliness of supply, and customisation are increasingly important, and which 'require a well-qualified workforce capable of rapid adjustment in the work process and continual product innovation' (Finegold & Soskice 1988, p.21). Guerrieri (1999) notes that, over the period 1970 to 1995, 'science-based' manufactures, including computers, telecommunications equipment, motor vehicle engines, aircraft, electric power machinery, and pharmaceuticals, accounted for all of the increase in manufactures in world merchandise trade.

This trade is being driven by the transfer of the production of low- and middle-value goods and services to developing countries, and the substantial rise in innovation-related investments in developed countries over the last two decades (Reich 1991; Wood 1994; Cully 1999; Maglen 2001). The skill level of these innovation-intensive industries is also rising. This is indicated by the rising share of professional and paraprofessional occupations, and a marked decline in the share of unskilled occupations in these industries. There are also demands for rising skill levels in VET-skilled occupations, especially trades and intermediate production workers, in relation to literacy, numeracy, computer competencies, behavioural skills and improved theoretical or conceptual understanding of the production process (Allen Consulting Group 1999; Toner & Wixted 2002).

Competitive success in innovation-based products and services will be an increasingly important factor in long-term national prosperity. It is crucial that the linkages and communication between innovation-intensive firms and vocational education and training are well defined and efficient.

Given that VET-skilled occupations, VET systems and innovation are the focus of this study, the following definitions are employed for the purposes of this chapter. VET qualifications are defined as an Australian Qualifications Framework (AQF) level of certificate I–IV or diploma. VET-skilled occupations are those which have been acquired through such VET qualifications typically classed under Australian Standard Classification of Occupations (ASCO) Major Group 3, *Associate professionals*, to Major Group 9, *Labourers and related*

workers[3] (Australian Standard Classification of Occupations skill levels 2–5). The VET system is defined as all public and private training providers, including non-conventional providers, such as equipment manufacturers, but excluding universities. The research uses the Organisation for Economic Co-operation and Development (OECD) definition of 'innovation' to identify innovation-intensive industries and firms, where innovation is defined as 'technologically new products and processes and significant technological improvements in products and processes … Innovations therefore involve a series of scientific, technological, organisational, financial and commercial activities' (OECD 1997, p.47). More specifically, certain firm or industry expenditures are deemed to be indicators of innovation activity. These include research and development; acquisition of new technology embodied in new equipment; tooling-up and industrial engineering; acquisition of patents, technology licences, trademarks; and workforce training related to the introduction of a new product or process (OECD 1997). Innovation intensity across firms and industries is defined as expenditures on innovation activities as a share of value-added or wages and salaries.

Research questions

The report addressed the following research questions:

- Which industries are most significant in undertaking innovation in Australia?
- What is the role and significance of VET provision in assisting Australian innovation?
- What is the occupational profile of innovative industries and which occupations within innovative industries rely on VET providers?
- How do innovation-intensive industries recruit, maintain and update their skills? What problems, if any, do innovation-intensive industries have in recruiting, maintaining and updating skills provided by the VET sector?
- What are the strengths and weaknesses of VET provision within Australia's innovation-intensive industries?

Project methodology

The following methods were used to answer the research questions.

To identify industries significant in undertaking innovation, an extensive array of data were collected relating to the innovation intensity of industries

[3] VET-skilled occupations are also found in Major Group 1, *Managers and administrators*, and Major Group 2, *Professionals* (Australian Standard Classification of Occupations skill level 1) but are generally achieved through a degree (McLennan 1997, pp.9–10).

and the relative contribution of these industries to total national expenditure on innovation in Australia. This is based largely on Australian Bureau of Statistics (ABS) innovation surveys and other economic data. These data were used to construct a composite index of innovation, ranking each industry in terms of their innovation intensity and contribution to total national expenditure on innovation. The benchmark is used to differentiate innovation-intensive and non-innovation-intensive industries.

A review of national and international literature focusing on the role of VET-provided workforce skills and VET skills formation systems in innovation was undertaken to identify the role of vocational education and training in Australian innovation. In addition, eight case studies of innovation-intensive firms were undertaken to investigate these issues, in particular, how innovation-intensive firms recruit, maintain and update their skills. All firms in the case studies had a large proportion of their workforce in VET occupations.

Extensive data analysis provided a comparative analysis of innovation-intensive industries and non-innovation-intensive industries in terms of their VET occupational structure, their role and significance in the VET labour market, and the training investments made by employers.

Literature on the links between VET and innovation

The literature on vocational education and training and innovation has identified a number of linkages between the development of a large and skilled, vocationally trained workforce within a country and the capacity of that country to undertake internationally competitive product and process innovation. This section briefly summarises the key arguments in this literature.

Drivers of innovation

The literature on innovation identified an interrelated set of factors strongly associated with innovation intensity in firms and industries. These include:

- large firm size
- research and development and other measures to promote product and process improvement
- regular upgrading of capital equipment
- strong linkages between producers and suppliers of capital equipment and other inputs
- customers who are demanding, in terms of quality, delivery times and product or service upgrading
- work organisation that encourages feedback from employees on product and process improvements

- competition within innovation-intensive industries and product markets based on product differentiation, reducing cycle times for introducing new products to markets, customisation, reliability, quality, design and integrating products and services
- well-functioning linkages between external research and educational institutions and firms
- regulatory requirements which allow for novel solutions in meeting prescribed standards.

The literature on the economics of vocational training identifies similar drivers as promoting comparatively high expenditure on workforce training across firms and industries (Wooden 1996a, 1996b; Toner 2000b; Ridoutt et al. 2002; Smith et al. 2002; NCVER 2002). Upon reflection, this is not a surprising result. The fundamental purpose of vocational training is, after all, the transmission of economically useful knowledge (Laplagne & Bensted 1999). Industries which experience comparatively rapid changes in the knowledge base of their processes and products require more intensive training to transmit this knowledge.

Learning by doing and using and technology diffusion

The literature demonstrates the key role of production, trade and technician-level occupations in the generation of new ideas and the all-important incremental improvement in the efficiency of production processes and product improvement (Koike 1988). In almost all fields of production of goods and services, the repetition of production tasks leads to a gradual improvement in the efficiency of production processes and product design and performance (Solow 1956). The importance of such 'learning by doing' has long been recognised, as has the central place of direct production workers in innovation as sources of work-based learning.

There are also quality and productivity improvements in the capital goods sector arising from experience in the use of these goods in production. The users of capital and intermediate goods provide feedback to the producers of these goods, communicating suggestions for design and other changes to improve the performance or reduce the cost of these goods. This is referred to as 'learning by using' or 'user-producer interaction' (Rosenberg 1982, pp.121–2; von Hippel 1988). The total productivity gains arising from the cumulative effect of these increments over several decades can be greater than the initial advance from the introduction of a new technology (Bessant 1992).

In summary, the literature indicates that a major contribution of VET-skilled occupations to innovation occurs through learning by doing and using. Secondly, such contributions flow from the practical involvement of these occupations through their direct engagement in the *design, installation, operation, maintenance and adaptation* of plant and production processes.

Finally, it is clear that work organisation design greatly affects the labour process, in terms of the breadth and depth of skills embodied in any particular VET-skilled occupation and the extent to which formal and informal processes within the workplace facilitate the transfer of knowledge and experience from VET occupations to management (Kerlsey & Martin 1997; Maglen & Hopkins 1998).

Matched plant studies

The analysis of the key role of VET skills in innovation and competitiveness received strong support in a comprehensive program of matched plants studies undertaken over the 1980s and early 1990s by the National Institute of Economic and Social Research in the United Kingdom. The matched plants were in Britain and several European nations. By comparison with these European countries, Britain has a much higher proportion of the workforce without qualifications and a much lower proportion of the workforce with vocational qualifications. These studies are summarised in Prais (1995) and Mason, Van Ark and Wagner (1996). These studies sought to account for differences in firm performance across countries by treating such differences as a dependent variable, and differences in training systems and skill levels as an independent variable. The object of the studies was to attempt to make a range of variables comparable, such as the type and quality of firms' output, production methods and equipment, so that the independent variable is limited to factors such as vocational qualifications, skills and training.

Depending on the commodity, productivity differences between British and European plants of 35% to 100% were observed. These results are consistent with productivity differences based on manufacturing census data across the countries (Prais 1995, chapter 3). In addition, the study also found large differences in the quality of commodities produced, with poorer quality in British products.

A number of skill and training-related contributors to the large differences in productivity and scope for product and process innovation across the case study plants were identified. The reasons for productivity or innovation differences between British and European plants included: defect rates; ratio of direct to indirect labour; utilisation rate of machinery; and flexible specialisation and skills. Each of these factors is elaborated in the following section.

Defect rates

A significantly higher defect and re-work rate in British plants across all product types led to lower physical output, and hence lower productivity. British plants employed quality control methods based on the rectification of faults in products at the end of the production line. The lower defect rate in Germany was the result of building quality assurance into German production processes. In turn, these differences arise from the employment of more highly skilled and trained production and maintenance people in German plants who are more

able to both identify and rectify faults in production processes and who operate machinery that permits more automated control of production processes and closer work tolerances.

Ratio of direct to indirect labour

The studies showed that the British plants had a much higher ratio of indirect labour, such as foremen, supervisors, clerical support and quality checkers. The employment of more semi-skilled people in British plants operating within a Taylorist work organisation, in which individual production employees acted with little autonomy, also necessitated layers of supervisors and management to monitor production and directly manage the introduction of new products and processes (Prais 1995, p.69).

Utilisation rate of machinery

Downtime due to machinery breakdown was in excess of 100% greater in Britain than in the European plants visited (Prais 1995, p.64). The much higher plant breakdown accounts for a large share of the productivity differences between British and European plants in the sample.

The higher rate of plant breakdown was attributed to inadequate plant maintenance in the British plants, and more specifically, inadequate preventative maintenance programs (Prais 1995, pp.61, 71). The much higher rate of plant breakdown and inadequacy of preventative maintenance are, in turn, 'attributable to … differences in the skill levels of maintenance teams—though inadequate technical skills at intermediate management level must bear a share of the blame' (Prais 1995, p.71).

Flexible specialisation and skills

Compared with their British equivalents, the German plants had, in general, a much higher rate of adoption of 'flexible specialisation' techniques. 'Flexible specialisation' is a production technique based on the use of programmable machinery, commonly referred to as computer numerically controlled equipment. It was found that, among the case study plants, German firms had 50% more computer numerically controlled machines than their equivalent British plants (Prais 1995, p.64). Flexible specialisation allows for much greater customisation of products and more rapid introduction of new products. The latter is also commonly referred to as reduced 'cycle times' for the introduction of product innovations; that is, products incorporating new designs, functions and components.

By contrast, the British plants operate more conventional mass-production methods. By definition, mass-production demands both the standardisation of the product and simplification of individual production operations through an intensive division of labour. These differences in production techniques and quality of output were attributed primarily to differences in workforce skills.

Opposing perspective

Cutler (1992) criticised these studies, but despite his wide-ranging critique, the National Institute of Economic and Social Research analysis remains crucially important in explaining, at least in part, the large differences in national and firm productivity, quality and scope for product and process innovation. At a minimum, the National Institute of Economic and Social Research studies confirm that: 'Firms' product market choices are constrained by the availability of necessary skills' (Estevez-Abe, Iversen & Soskice 2001, p.146).

Trade patterns and training

A related approach to examining the links between innovation and vocational skills has been to examine cross-country differences in trade performance and differences in the composition of workforce skills (Oulton 1996). A recent major study compared the long-run rate of growth, from 1976 to 1994, in exports of three types of manufacture (low, intermediate and high-skill products) across a number of high-income OECD countries and for the world as a whole (Crouch, Finegold & Sako 1999). It was found that both Germany and Japan had a significantly higher growth rate of exports of intermediate-skill products (defined as engines, machine tools, metal machine tools and non-electric machines, and power-generating equipment) than for the world as a whole. Further, the growth rate of intermediate-skill product exports from Germany and Japan was 60% faster than that of Britain and the United States. The situation was reversed, however, for high-skill products (defined as organic and inorganic chemicals, pharmaceuticals, office equipment—including computers, dyes/paints and petroleum/gas products). In this case, Germany has below-average growth in world trade, with the United States substantially above the world average. The United Kingdom was only marginally above the world average growth. Finally, for low-skill products (defined as meat, rubber, rubber products, leather and textiles), most of the high-income countries had substantially below-average growth in world trade. This is due largely to intense competition from developing countries in these products. The United States however, was only marginally below the world average growth rate in low-skill products (Crouch, Finegold & Sako 1999, pp.103–5). The study also noted that both the United Kingdom and United States export a much smaller proportion of their manufacturing output than other advanced countries (Crouch, Finegold & Sako 1999, p.107).

These trade patterns were argued to reflect differences in the national composition of skills and skill formation systems. Both Germany and Japan have particular strengths in production, trade and technician-level training. Both countries 'provide broad-ranging, company-based training for particularly high proportions of their workforce' (Crouch, Finegold & Sako 1999, p.106). By contrast, the United States and the United Kingdom provide a much smaller proportion of their workforce with the opportunity to acquire skilled vocational qualifications.

Both the United Kingdom and the United States have world-class university education systems, notably in science and technology fields. This is reflected in above-average performance in high-skill intensive exports in both countries. This has led to 'strong performance in some highly skilled sectors', but their overall trade and industrial structure is 'bifurcated between high and low-skill activities' (Crouch, Finegold & Sako 1999, p.215). The export volume of these high-skill products from the United States and United Kingdom is small by comparison with their imports of intermediate-level products. Consequently, both countries run substantial merchandise trade deficits (Crouch, Finegold & Sako 1999, p.107).

This analysis is relevant to Australia, as the VET skill structure of its workforce is approximately mid-way between European nations, which have a highly developed VET skills formation system, and that of the United Kingdom. Compared with Britain, Australia has a higher share of its workforce with either vocational or craft qualifications, and a lower share with no qualifications. Compared with European nations, Australia has been a relatively low investor in technical skills (Marceau, Manley & Sicklen 1997, pp.8.1–8.21). The linkages between skills and export success in higher value-added manufactures in Australia would also appear to be similar to those in other countries, in that Australia also has growing trade deficits in skill and innovation-intensive manufactures. The deficit in what are termed 'elaborately transformed manufactures', such as motor vehicles and machinery, is equivalent to over 10% of Australia's gross domestic product (Toner 2000a). However, the industrial structure of a country is affected by a multitude of factors, not just the quantity and quality of vocational education and training and other skills. These factors include, for example, national industry policies and endowments of raw materials.

The relationship between national VET systems and product market specialisation and strategies is amplified in the following section.

Institutional foundations of national differences in VET systems and innovation

The literature on comparative international VET systems has a number of findings relevant to the study of the links between vocational education and training and innovation. This literature identifies a variety of specific features in the political economy of countries which give rise to a diversity of national vocational training systems and associated product market and innovation strategies (Finegold & Soskice 1988; Keep & Mayhew 1999, p.5). For example, both Germany and Japan have very different skill formation systems, although as we have seen, they have a strong performance in VET-intensive 'middle skill' manufactures. The German VET system is reliant on 'industry specific' skills generated by a highly regulated apprenticeship system, in which state and national laws govern the content and duration of training and the testing and accreditation of apprentices. It is also a training system involving a high level of

employer and employee coordination and cooperation. The state also plays a major role in the provision of off-the-job vocational training through a variety of technical institutes and colleges. The accreditation of training in Germany applies to a set of discrete skills accredited to a known standard which are embodied in widely recognised occupations, the pattern of work organisation and the industrial relations system. This facilitates labour mobility, since prospective employers can have some confidence in the 'quality' of the labour power they are purchasing.

The production of 'industry specific skills … acquired through apprenticeship and vocational schools' is a key foundation for the German manufacturing 'high quality product niche strategy' (Estevez-Abe, Iversen & Soskice 2001, p.148). This skill formation system is also underpinned by a variety of 'social protection' mechanisms, such as those relating to security of employment and unemployment payments, and comparable wages for similar work within and across industries. Such protection is required to redress potential market failure in the investment of firms and individuals in industry-specific skills (Estevez-Abe, Iversen & Soskice 2001, p.145). This arises from the assumption that the acquisition of firm- or industry-specific skills, as opposed to general skills, increases the risk of unemployment by reducing the pool of potential employers for people with firm- or industry-specific skills. Hence, 'all countries with a strong emphasis on industry-specific skills have developed effective wage co-ordination at the industry level' which is achieved through 'collective wage bargaining' (Estevez-Abe, Iversen & Soskice 2001, p.177).

By contrast, the Japanese system, especially within large corporations (Dore 1973; Koike 1988), is much more firm-specific and multiskilled than the German system. These differences reflect the much lower level of labour turnover within large Japanese corporations, creating an incentive for large Japanese firms to invest heavily in their employees, and an acceptance on the part of their workers of training that is more biased towards firm-specific skills. Multiskilling and a high level of functional flexibility (or comparatively low level of occupational demarcations) are encouraged by the linking of pay to experience and time served with the firm, rather than to current production tasks undertaken. In addition, the premium placed by larger Japanese corporations on job security has been argued to significantly reduce resistance to the introduction of potentially job-displacing new technologies (Cole 1992, pp.196–200). Another essential feature of the Japanese VET skill formation system is the high degree of cooperation, especially in technology transfer, including skills training, between larger firms and their sub-contractors and across sub-contractors (Sako 1996). Over the later 1990s there have, of course, been changes to supporting features of the Japanese internal labour market, such as the decline of lifetime employment and time-served-based pay scales (Curtain 1994).

However, under certain circumstances, innovation and high productivity have been achieved without the development of large-scale, high-quality

vocational training for production and craft-level occupations. In the United States during the nineteenth century, for example, the combination of rapid economic growth and skilled labour shortages stimulated the development of capital-intensive mass-production methods (Crouch, Finegold & Sako 1999). As Elbaum notes: 'US firms led the way in substituting machinery for craftsmen and in dividing traditional craft jobs into simpler constituent tasks that could be reassigned to less skilled workers' (1991, p.208). In turn, this reinforced the comparatively poor development of the apprenticeship system, craft skills and production workers. Large parts of American manufacturing produce high-volume standardised products using mass-production techniques with an extreme division of labour, requiring low vocational skills and a heavy reliance on university-trained engineers and managers for plant coordination, quality improvement and direction of innovation.

It has been argued that the comparatively low level of employment and unemployment protection in the United States creates a strong incentive for workers to invest in general or transferable skills. With low levels of protection, the best insurance against labour market risks is for the worker to invest in general, or highly portable skills which are valued in the external labour market (Estevez-Abe, Iversen & Soskice 2001). The United States can be regarded as the 'archetypal case of a country with a weak company and vocational training system, but a very advanced higher education system. Indeed, a college education in this country is widely considered the only effective insurance against an otherwise highly volatile and uncertain labour market' (Estevez-Abe, Iversen & Soskice 2001, p.172). In the United States the reluctance of workers to invest heavily in specific skills creates an 'incentive for firms to use technologies that rely least on specific skills; this, in turn, increases the demand for general skills, and availability of general skill jobs makes general education more attractive to workers, thus creating a self-reinforcing dynamic' (Estevez-Abe, Iversen & Soskice 2001, p.162).

Skill formation in companies which intensively use firm- and industry-specific vocational skills will be based on 'deep competencies within established technologies' in terms of incremental improvements in quality and diversification of existing product lines (Estevez-Abe, Iversen & Soskice 2001, p.174). This is consistent with the international trade data reported earlier which showed that Germany and Japan were particularly strong performers in 'middle skill' manufactures (such as engines, machine tools, metal machine tools and non-electric machines, and power-generating equipment). A different competitive advantage, and consequent product market strategy, applies to United States firms where there is a large pool of workers with advanced and highly transferable skills, especially in science, technology and management fields, and where social protection is low. This advantage is based on considerable flexibility in the utilisation and deployment of labour, and a 'high responsiveness to new business opportunities … [which] facilitates the use of rapid product innovation strategies' (Estevez-Abe, Iversen & Soskice 2001,

p.174). This proposition is also consistent with the international trade data which showed that the United States had a significantly higher growth rate of exports of high-skill products (organic and inorganic chemicals, pharmaceuticals and office equipment). These are products which are particularly intensive in their use of advanced scientific and engineering skills and research and development.

There has been little analysis of the Australian VET system from the perspective summarised above. However, it has been observed that, as in Germany, the core element in the VET system is the acquisition of 'industry-specific' skills through an apprenticeship system (Curtain 1987).

There are a number of important policy implications which have been drawn from this literature. Firstly, the embeddedness of VET systems in the specific histories and political economies of nations implies that there are considerable difficulties in countries wanting to emulate another country's high-skill, high-innovation strategies (Campbell 1991, p.165).

Secondly, it is essential for policy-makers to recognise that improved skills and higher qualifications are a necessary, but not sufficient condition for the growth of innovation-intensive industries (Cutler 1992; Keep & Mayhew 1999, p.12). Other institutional supports and complementary policies, in addition to improved skills, are essential. The latter include, for example, taxation policies favoring innovation, such as accelerated equipment depreciation and research and development investment allowances.

Finally, analysis of the economic and institutional foundations of VET systems leads to the conclusion that the American system of production is not a feasible direction for Australian industries. As noted before, large parts of American manufacturing produce high-volume standardised products using mass-production techniques, which rely on university-trained engineers and managers for plant coordination, quality improvement and direction of innovation.

> *Given both the smallness of Australia's domestic market and the proximity of large amounts of relatively cheap labour, the American route of mass production of manufactured goods is clearly not a viable option.*
>
> (Maglen & Hopkins 1998, pp.22–3)

Again, as described above, other large parts of American manufacturing are highly intensive in terms of innovation and research and development, producing substantially above-average levels of world trade in 'science-based' products and heavily reliant on graduates from world-class research universities. However, as explained in reports on this topic by the Department of Industry, Science and Resources (1996), Marceau, Manley and Sicklen (1997), and the Department of Employment, Science and Training (2002), for a broad range of structural reasons, Australia is a comparatively poor performer in terms of private expenditure on innovation and research and development. These reasons include small average firm size, low share of manufacturing in

gross domestic product, heavy reliance on imported technologies as a result of a high level of foreign ownership in strategic sectors and a history of internationally uncompetitive government innovation incentives. It must be noted that, as a result of government policy changes over the last 15 years, Australian private investment in innovation expenditures has increased, although so also has the performance of other OECD countries, resulting in little change in Australia's relative standing on innovation 'score cards'.

Addressing the research questions

The following answers to the research questions are based on the literature review, analysis of quantitative data (mostly from the Australian Bureau of Statistics) and the eight case studies.

Which industries are most significant in undertaking innovation in Australia?

A composite index of innovation was constructed to identify innovation-intensive industries. As noted earlier, OECD definitions were used to define and quantify industry innovation expenditures and included research and development, capital investment in new plant and equipment, and structured training. The index compares both the level and intensity of innovation expenditures across industries. The level of expenditures is an industry's share of total expenditure on each of the three innovation expenditures. This quantifies inter-industry differences in the contribution to total national innovation expenditures. Intensity of innovation is defined as the ratio of an industry's expenditure on innovation to the industry's value-added or gross wages and salaries. Given volatility in these expenditures from year to year, several years of data were used in constructing the index.

A clear hierarchy is apparent in the innovation intensity of Australian industries, with the industries clustered into three distinct groups. These groups are:

- *high innovation-intensive industries*: mining; manufacturing; property and business services; and communication services
- *medium innovation-intensive industries*: electricity, gas and water; wholesale trade; finance and insurance; and transport and storage
- *low innovation-intensive industries*: personal services; retail trade; cultural and recreational services; health and community services; and construction.

It is of interest to note that the high innovation-intensity group comprises two traditional goods producers—mining and manufacturing—as well as the most recently developed and fastest growing service industries—property and

business services, and communication services. It reveals that the more popular notions of what constitutes technologically dynamic industries require change. In 2001 these four industries accounted for 33.5% of gross domestic product and 26.3% of employment. The fact that the share of gross domestic product significantly exceeds the share of employment reflects the comparatively high productivity of these industries.

It is also important to acknowledge the limitations of a purely 'data driven' identification of innovation-intensive industries, especially an approach based on highly aggregated data. The use of aggregated industry-level data masks considerable intra-industry differences in the push for, and intensity of, innovation. For example, the low ranking of the health and community services industry is problematic since a large section of the health industry is highly innovation-intensive, in terms of research and development, investment and training. However, this is obscured by its aggregation with the low innovation-intensive community services industry. These problems were addressed, at least in part, through the selection of the case studies which included certain high innovation activities within public sector organisations which would otherwise have been excluded from the analysis.

What is the role and significance of VET provision in Australian innovation?

The eight case studies demonstrated that innovation-intensive firms regard vocational education and training as a critical transmission mechanism in the diffusion of knowledge and development of practical skills for a very broad range of occupations. This finding is supported by ABS surveys of innovation-intensive industries which found that firms identified VET-skilled occupations amongst all occupational groups as principal sources of ideas for technological innovation.

ABS data indicate that innovation-intensive industries have higher expenditure on structured training as a share of gross wages and salaries and provide notably higher hours of training per employee. The case study firms spent two to four times more on training as a share of gross wages and salaries than other firms. A common element across all case studies was that training was seen as an essential element in the maintenance and growth of their business, and flowed automatically from their decisions regarding the pursuit of product and process improvements. This reflects the bases of competition within the industries and the markets into which they sell. Competition for the case study firms, and the broader innovation-intensive industries, is based on the development of novel products and processes, design, marketing, customisation, quality, and the integration of products and services (Porter 1985, 1990). By contrast, in other industries such as primary production, transport, residential construction and retail, price is a significantly more important basis of competition.

The case studies confirm findings in the literature review that work organisation practices within firms which encourage worker consultation result in valuable contributions from VET-level occupations into product and process improvement. All of the case study firms had formal or informal mechanisms for stimulating such contributions.

What is the occupational profile of innovative industries and which occupations within innovative industries rely on VET providers?

Nearly half of all employed persons work in low innovation-intensity industries, just under one-third work in high innovation industries and the remainder, about one-fifth, work in medium innovation-intensive industries. The high innovation-intensive industry group as a whole has a disproportionately large share of managers/professionals and trades and advanced clerical occupations (table 1). All other occupational groups are under-represented in the group.

Table 1: Percentages of occupations in workforce for all industries compared to innovation intensity of industry, Australia 1996

Occupations	Innovation intensity of industries			All industries
	High (%)	Medium (%)	Low (%)	Total (%)
Managers & professionals	26.8	19.2	19.0	**21.5**
Associate professionals	10.1	11.6	14.6	**12.6**
Trades & advanced	22.3	15.2	19.9	**19.8**
Intermediate	23.0	44.5	22.6	**26.8**
Elementary	17.9	9.6	23.9	**19.3**
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: Unpublished data from 1996 Australian Bureau of Statistics Census of Population and Housing

However, within the four industries comprising the high innovation-intensive category (mining, manufacturing, communication services, and property and business services), there is very considerable diversity in their occupational structures. Indeed, the degree of variation in the occupational structure across these four innovation-intensive industries is as great as that across all industries.

In other words, taken collectively, there are significant differences in the occupational structure between the high innovation-intensive group and the other two groups. However, taken as separate industries, these differences become much less distinct. The fact that the association between occupational structure and innovation intensity of industries depends on the level of analysis undertaken, suggests that the association is not robust.

Another important and related finding is that the variation in educational attainment within the innovation-intensive industries is as great, if not greater, than that across all industries. This is primarily due to the large variation in occupational structure across the four innovation-intensive industries. These results suggest strongly that the principal occupational groups play a different role, and are of differing significance, in the innovation process within each of the high innovation-intensive industries. For example, in the manufacturing industry, only 11% of employees have graduate or postgraduate degrees, compared with 33.6% for property and business services.

These results also suggest that by itself, educational attainment, in particular, a high proportion of an industry's workforce with university qualifications, is not a strong predictor of innovation intensity. For example, of all industries, the health and community services industry has the highest share of persons with university qualifications, at 40.4%, although it is classified to the low innovation group. (Note, as before, that the aggregation of health and community services obscures the relatively high innovation intensity of the health industry.) This finding is consistent with the literature on innovation, which finds that a very broad range of factors, both internal and external to a firm and industry, determine the intensity of its investments in innovation-related activities.

How do innovation-intensive industries recruit, maintain and update their skills? What problems, if any, do innovation-intensive industries have in recruiting, maintaining and updating skills provided by the VET sector?

On the basis of the ABS data and the case studies, innovation-intensive firms use a wide range of training providers. These include TAFE, private providers, equipment and other vendor suppliers, professional associations and in-house providers. Amongst higher-level VET-skilled occupations, such as technical officers or those with diplomas and advanced diplomas, conferences, journals and professional associations were an important means of keeping up to date with advances in their fields. Nevertheless, a key role was identified for TAFE, in that six of the eight case study firms used TAFE to supply entry-level qualifications. The term 'entry-level' training covers minimum VET qualifications for recruitment into the range of VET-skilled occupations and the upgrading of qualifications by existing employees who seek entry into higher-level positions within the firm. Of the two firms which did not use TAFE as a provider, one firm was negotiating with TAFE to develop a course covering key production occupations. The other firm delivers its own training with a course developed in conjunction with TAFE and in which TAFE plays an important role in maintaining the quality of workplace competency assessment.

Across the case studies there was a universal requirement for entry-level VET training to result in formal qualifications. This was due to the widespread adoption by larger firms of:

- enterprise bargaining agreements providing for training to lead to the acquisition of recognised, transferable qualifications
- formal quality assurance methods which typically require that employees document their competency to perform the range of work they undertake
- formal human resource management policies in which recognised qualifications are used as criteria in recruitment and promotion.

From the case studies a classification was developed to describe and explain inter-firm differences in the methods and sources used to recruit, maintain and update vocational skills. The picture that emerges from this classification is of a highly adaptive training system. The key features of the classification include models where:

- New entrants or existing workers receive their vocational qualifications by participating in courses of study developed for a general industry based on national training packages with the course conducted in a TAFE institution (the standard model).
- Firms seek to have externally provided and recognised courses and qualifications, but significantly modify the content, assessment and delivery methods.
- Firms rely on an external provider for the basic entry qualification, but this is supplemented concurrently with extensive in-house provision.
- Firms provide extensive in-house training, although also relying on the domestic VET system for specialist assistance.
- Firms require recruits to have vocational education and training or university qualifications, but these are regarded essentially as a screening device to demonstrate recruits' interest in and aptitude for the type of work to be undertaken. For a variety of reasons these firms supply extensive post-recruitment in-house training, although this is not closely integrated with the wider VET system.

In addition, within the case studies, there were three distinct patterns in the recruitment of persons for VET occupations. These recruitment patterns are:

- Entry-level training is supplied concurrently with employment upon entry to the firm.
- People are recruited having completed the necessary entry-level qualification, although ongoing support is provided by the firm for upgrading qualifications to higher levels.
- A combination of both above approaches to recruitment and training is used.

These differences in training and recruitment patterns largely reflect differences in the availability of an external labour market for the skills required by the case study firms. Where this external labour market does not exist, say for companies introducing firm-specific technologies novel within Australia, recruitment and training are necessarily supplied concurrently.

What are the strengths and weaknesses of VET provision within Australia's innovation-intensive industries?

The case studies revealed, overall, a high level of satisfaction with the public and private VET system. Staff interviewed for the case studies all commented very positively on training provided by TAFE, especially in relation to its emphasis on the acquisition of practical skills. A number of firms explicitly contrasted the general and theoretical orientation of university education to the more pragmatic training provided by TAFE. Training with a practical and applied orientation was valued because it reduced the amount of on-the-job training required for employees to become productive. Firms also commented positively on the link between off-the-job training and on-the-job work experience, allowing students to apply their knowledge.

An important implication of this finding is that VET institutions must understand their competitive strengths and avoid the temptation of converting TAFE institutes into quasi-universities. This, of course, is not to argue against the role of TAFE in the provision of higher-level theoretical skills, especially in fields of rapid technical advancement which require these skills. Rather, the issue is to ensure an appropriate balance of practical and theoretical skills. Close collaboration and consultation with industry partners is the best method to ensure this balance.

An obvious, although still key finding was the importance of consultation. The researchers concluded that the satisfaction expressed by firms regarding TAFE training was due to the high level of consultation evident between the firms and TAFE. Consultation is intended to ensure that the training offered meets the firms' needs. It must be recognised, however, that a crucial basis for the generally high level of satisfaction and high level of consultation is the large size of the case study firms. (Employment within the case study firms ranged in size from 70 to over 500, with an average of 380.) Large firms have the internal resources and specialised staff to customise their training needs, consult extensively with TAFE and monitor performance. The scale of training sought by the firms made it economically feasible for TAFE and other providers to customise course content, assessment and delivery. The scale also made it feasible for VET providers to invest in the development of their own staff, thereby enabling them to keep abreast of the latest technologies and teaching/learning strategies in their fields.

A considerable amount of post-entry-level training was provided, mostly in the form of short courses, typically with a duration not exceeding two to three

days. The case studies and survey data indicate that a wide variety of training providers were used for this post-entry-level training. In approximate order of importance, they included equipment and other input suppliers, in-house training, private providers and TAFE. Firms sought flexibility in training arrangements for this post-entry-level training, especially the capacity for on-the-job delivery and customisation of training to conform to firm-specific operating procedures and equipment. On the basis of these case studies, this flexibility was provided to them.

Two constraints were identified on the capacity of the VET system to meet the skill needs of innovation-intensive firms. Firstly, all of the case study firms emphasised the need for employees to develop behavioural skills, such as effective teamwork, and to develop problem-solving and communication skills, including improved literacy, numeracy and information technology skills. In the view of the respondents, these are skills that are not adequately taught in the VET or university systems. Across the case studies these behavioural skills were acquired mostly on the job. Other studies have also identified the increasing importance of these behavioural skills in industry (Dumbrell, de Montfort & Finnegan 2002; Smith et al. 2002). Demand for these behavioural and communication skills results from:

- the demands of formal quality assurance systems
- the automation of production, requiring operators to have a higher-level conceptual understanding of production processes
- a change in work organisation leading to flatter management structures and devolution of responsibility to supervisors and operators
- the expectation that employees contribute to product and process improvement through various consultative mechanisms.

Secondly, there has been a significant reduction in firms' investment in the apprenticeship system. For over three decades until the early 1990s, the training rate averaged 12.7%. (The apprentice training rate is defined as the ratio of apprentices in training to the stock of employed tradespersons.) From 1993 to 2001 the total annual average training rate was 10.6%. This represents a decline of 16%. There were even larger falls for trades such as electrical, metal and construction (Toner 2003). This has contributed significantly to skill shortages in these occupations. This study has shown that these VET-skilled occupations are critical to success in innovation-intensive export and import-replacement manufacturing.

Conclusion

The key conclusions are, firstly that innovation-intensive firms are also training-intensive firms. This is due to the fact that most of the drivers of innovation also promote above-average training expenditures per employee. Secondly, it follows

that an important means of increasing the level of VET training is to encourage the development of innovation-intensive industries. Thirdly, in Australia, VET-skilled occupations were found to make an important contribution to innovation activities. This is due to their practical and direct engagement in the design, installation, operation, maintenance and adaptation of plant and production processes. Fourthly, firms expressed a high level of satisfaction with TAFE and other VET training providers. This satisfaction is explained in part by the large size of the innovation-intensive firms, as the level of demand generated by these firms for training made it economically feasible for the training providers to customise courses, provide flexibility in delivery, and invest in upgrading the skills of their teachers. Fifthly, among high-per-capita-income OECD countries, there are large differences in national training systems in terms of their propensity to produce industry-specific, firm-specific or general skills. In turn, these differences produce large variations across countries in the types of national innovation systems and product market strategies adopted by firms. Finally, VET skills are a necessary, but not sufficient, condition for innovation to occur. Other supporting institutions and government measures relating, for example, to industry and tax policies, are also required.

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Vocational education and training and the commercialisation of Australian research

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This chapter is based on the findings of research conducted by the authors between 2000 and 2002.[1] The research explored the relationship between the vocational education and training (VET) sector and Australia's co-operative research centres, which were established to undertake applied research and to promote its commercialisation. It showed that there is a need to improve such connections in order to ensure effective dissemination of Australian research findings from co-operative research centres. This can be achieved by investing in vocational education and training to ensure that people have the skills required for working with the new systems, tools and processes generated by the innovation process. The work raised important questions about the role of vocational education and training in the national research effort, and the VET response to the changes in skill needs which arise as innovations are adopted by industry.

Introduction

TRADITIONALLY, AUSTRALIA HAS relied heavily for its economic success on exploiting its natural resources, and thus on industries such as agriculture and mining. However, in the developing global knowledge economy,

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many of our traditional industries are in decline and there is a new urgency to identify other sources of employment and earnings. Thus the need to encourage and nurture new ventures is critical. Australia now has to act swiftly and boldly to support good ideas and the new and changed industries they create.

Workforce skills will be one of the 'critical success factors' for emerging and changing industries in the next decade. These skills are crucial for existing industries to maintain a competitive advantage in the global knowledge economy. However, in the past, there has often been a time lag between the identification of a skill need and when 'the education sector responds to industry's needs for people skilled in a particular area' (Department of Industry, Science and Resources 1999a, p.10). If Australia is to support and nurture its new industries, reducing this time lag must be given a higher priority. As a major player in workforce skills formation, Australia's VET system must play an important role in meeting this challenge. But how does the VET system obtain the information it needs to fulfil this role? When should it respond and what kind of response should it make?

This chapter outlines the findings of research that set out to address these questions by investigating the relationship between VET and a component of the National Innovation System, specifically the Co-operative Research Centre program.

Co-operative research centres

The Co-operative Research Centre program is unique in the National Innovation System in its strong commitment to applied research and to the implementation and/or commercialisation of the research outcomes. Its main aim is to strengthen collaboration between researchers, research organisations and research users, in order to 'obtain better value from Australia's investment in R and D' (Mercer & Stocker 1998). It does this by promoting long-term cooperative relationships between researchers and research groups located in universities, Commonwealth Government and state and territory government research laboratories, and the private sector. The relationships promote a flow of knowledge and ideas in both directions to enable the research to assist in the resolution of current problems. End-user involvement in the research also speeds up dissemination of results and implementation of new products or processes.

There are a large number of centres (usually over 60) and they work in six different fields of research (see table 1). They are also large in financial terms, with an average budget of about $7 million per centre per year, each supporting about 30 full-time research staff and several research programs.

The exact number of centres varies as they have a time limit of seven years on their operations. Furthermore, if the centre has achieved its aims and has no need to continue, it can close. Similarly, if the centre cannot achieve its purpose,

it will not be re-funded and so closes—hence the growing imperative to produce significant results in the seven years in order to gain a second round of funding. Some centres have closed, with the core staff rolling over into a new centre which builds on the previous centre's work; alternatively, the technology developed in an expiring centre is refined and applied in another centre's research program. This was the case when the co-operative research centre, Australian Mineral Exploration Technologies expired and Landscape Evolution and Mineral Exploration took up the exploration technology and further developed its applications.

At the beginning of this research 67 centres were active. However, over the 18-month period of the project, the contracts for a number of centres had expired and they were not renewed. This meant that, by the time of the telephone interviews, these centres had no staff available for interview. Therefore the inclusion of expired centres in the totals relates to the initial group of 67 centres to be investigated in the research.

Table 1: Co-operative research centres by field of research, mid-2000

Research field	Number of centres
Agriculture and rural-based manufacturing	16
Environment	13
Information and communication technology	6
Manufacturing	9
Medical science and technology	10
Mining and energy	10
Term expired/closed centres at start of research	3
Total co-operative research centres	**67**

Source: www.crc.gov.au

A review of the annual reports for 2001 for these centres found that most were engaged in gradual rather than rapid innovation, and were oriented to achieving improvements in existing industries rather than producing technologies, products or processes for new industries or markets. Each of the annual reports provided information about several research programs, each of which contained number of projects.

The potential for the emergence of new industries, at least in the immediate future, appeared to be very limited, although, if the products and processes resulting from the work of the centre were applied in existing industries, they might still require some new or different skills. Their work had the potential to make some existing skills obsolete, as well as require some new skills.

In this context therefore, overall, about 60% of the research programs conducted by the centres were being undertaken in areas where there was an existing VET program or course. This varied from one field to another, but was

highest in the environment and information and communications technologies and lowest in the mining and engineering fields (see table 2).

Table 2: Research programs in the co-operative research centres and their relevance to VET programs by field

Research field	Relevant to VET programs	%
Agriculture and rural-based manufacturing	38 of 53	72
Environment	46 of 59	78
Information and communication technologies	19 of 26	73
Manufacturing	24 of 37	64
Medical science and technology	12 of 37	32
Mining and engineering	12 of 43	28

Table 3 provides some specific examples of the work of the centres, work which has the potential to demand new or changed skills in areas where the VET sector currently plays, or has the potential to play, an important role in skill formation. Whether or not the developments indicated in table 3 impact on skill needs depends to a large degree on the extent to which industries and enterprises choose to adopt or implement the new equipment, tools, work practices etc. emerging from the centres. Thus the effectiveness of the commercialisation and dissemination strategies of the various co-operative research centres is crucial.

Table 3: Co-operative research centre research—potential skills relevant to the VET sector

Co-operative research centre	Research and VET-relevant skill impact
Australian maritime engineering	New ship design and construction systems and processes which may impact on skill requirements are being developed.
Materials welding and joining	New welding methods and procedures for quality welding are being developed.
Bioproducts	New products generated will eventually be applied in commercial food production.
Intelligent manufacturing systems and technologies	A change in basic skills may be required if the new processes etc. are taken up widely in industry.
*Cast metals manufacturing	Technology is being developed in the cast industry for greater efficiency.
*Australian photonics	Photonics is a new technology being embodied in new products. Technicians will be required for manufacturing, service and maintenance of these products.
Sensor signal and information processing	New services/products will allow tasks previously carried out by experts to be undertaken by technicians.
*Satellite systems	Satellite solutions will require technical skills for operation.
Australian mineral exploration technologies	New products and processes for mapping the regolith will be useful in the fight against salinity and will change the current practices of geologists, drillers and environmental managers.

*Landscape evolution and mineral exploration	Tools for mapping landscapes and assessing salinity will require new skills in geophysics, data collection and analysis.
Mining technology and equipment	Developing new equipment for underground vehicles will require new skills for their operation.
*Renewable energy	Increasing the efficiency of existing products and developing new products will require new and upgraded skills.
*Viticulture	A focus on product and process improvement will require some skill upgrading.
The cattle and beef Industry (meat quality)	Developing new practices and processes will enhance quality and sustainability.
Aquaculture	New processes, technologies, systems and stock lines are being adopted in this new industry.
Sustainable cotton production	Developing new agricultural practices for sustainability and ecological safety will impact on production and therefore skills.
Sustainable sugar production	Changes to work practices will be required for new processes being developed.
*Sustainable rice production	New methods and processes are being developed to minimise water use and to increase efficiency and product quality. Changes to current practices will be required.
*Waste management and pollution control	Developing high-technology solutions for recycling and re-use of waste will have consequences for operator skills and new management approaches.
Quality wheat products and processes	Developing techniques and processes to enhance product quality will require skill upgrading.
Molecular plant breeding	New methods for improving disease resistance, minimising climate stressors and increasing quality are being developed with consequent skill requirements.
The Great Barrier Reef world heritage area	New management tools to support the Great Barrier Reef ecosystem are being developed.
Tropical rainforest ecology and management	New environmental management, eco-tourism and heritage processes will require new and revised skills.
Conservation and management of marsupials	New approaches are being developed which are of relevance to veterinary nursing.
*Water quality and treatment	New processes and management systems are being developed and new skills will be required.
Weed management systems	High-tech solutions are replacing low-tech solutions with consequences for operator skills.
*Sustainable tourism	The centre is working out ways in which the principles of sustainable development can be applied in the tourism industry. New skills will be required in all aspects of the industry's operations, including resort design and development, management and evaluation.
Tissue growth and repair	Research program in wound repair may impact on nursing skills.
Cochlear implant and hearing aid innovation	Training for audiometrists is required to deal with new products being developed.

Note: * Case studies conducted in these centres

Selection of case studies

As indicated in table 3, to undertake this research, case studies were selected from ten co-operative research centres to enable more detailed investigation of their connections, or possible connection with the VET system, and their perceptions of future training needs. The review of the annual reports identified centres (both individually, and in selected groups) which would be particularly interesting or representative case studies. A telephone survey of the centres was conducted to further investigate any connections with the VET system. Initially it was believed that the selection of cases should include at least one industry from each of the four stages of industry development; that is, future, emerging, new and mature. Subsequently, it was decided that clearer distinctions needed to be drawn between different types of skill needs, and hence centres which demonstrated few future skill needs or skill needs of greater relevance to higher education than VET, or both, were excluded from further consideration. The ten case studies illustrate industries at different stages in their development, including mature industries, in areas where:

- significant skill needs are currently not being met by the VET sector
- stronger connections with the VET sector would be beneficial
- significant skill needs are indicated in the future.

VET–co-operative research centre connections

In spite of substantial evidence of the relevance of the work of the co-operative research centres to VET, very few of the 2001 annual reports documented any connections with either individuals or organisations within the VET system. There was little evidence of awareness that their work might have implications for vocational education and training, or that VET involvement could make a useful contribution to it. Only one centre (Australian photonics) had a VET organisation among its partners; less than a handful had VET associates and a small number were very closely connected with Aboriginal communities and, as a result, engaged with VET.

Given the close links between the VET system and industry, the neglect of the VET sector seemed to be particularly marked. Co-operative Research Centre program guidelines call for substantial collaboration with industry and thus all centres indicated strong connections with a variety of players in the industries for which their work was expected to be most useful (Department of Industry, Science and Resources 1999b). The only exceptions to this were two cases in which centres were working in an area where there was no well-established Australian industry—satellite systems and photonics. Industry partners were also often used in the commercialisation of research outcomes. As part of their

dissemination and utilisation programs, several centres also offered training programs and workshops for existing industry workers.

However, the further investigations through a telephone survey and case studies uncovered considerable diversity in the relationships between centres and VET. A five-category classification of the connections was developed: none, nascent, incidental, informal and strong. A sixth category, 'should be', identified centres which had no connection with VET but which had research programs in areas where there are currently specified VET courses or a recognised training capability. Table 4 outlines the six categories.

Table 4: Categories of VET–co-operative research centre connections

Connection type	Description
Strong	committed relationship generally formalised in an agreement or strong personal long-term commitments
Informal	links that support intermittent information transfer or efforts to form links
Incidental	one-off contacts to address a specific need, often relying on informal individual contact from either the CRC or VET
Nascent	perceived value by CRC in a connection with VET and looking to connect but has had no previous connection
None	no connection evident
Should be	research programs align with VET areas

It was not always easy to assign a centre unequivocally to a particular category. The relationships between a centre and the VET sector tended to change over time, even during the period in which the research was conducted. This may in part reflect our intervention, which tended to produce a growing awareness and recognition of the VET sector as a user, or potential user, of the particular centre's research and knowledge. Sometimes also, the boundaries between categories became unclear, thus reinforcing the notion of a continuum of relationships rather than clear groupings.

The distribution of connection types across the industry sectors covered by the centres as shown in table 5 shows an interesting perspective on the VET sector–centre relationships. This table demonstrates that there are more robust links in the fields of agricultural and rural-based manufacturing, environment and manufacturing technology than in information and communication technologies, mining and energy and medical science and technology. This is not surprising, given that VET has a substantial training base in the 'strong' areas. However, there are also high numbers of 'informal' and 'incidental' links in these areas. This indicates that there may be significant room to develop and strengthen these weaker connections with VET.

Table 5: Co-operative research centres and their connections with VET by industry sectors

Industry sector	Strong	Informal	Incidental	Nascent	None	Term expired
Agriculture and rural-based manufacturing	3	2	2		4	5
Environment	2	4	1	2	3	2
Information and communication technologies	1			1	3	3
Manufacturing	2	4	2	1		
Medical science and technology	1		1		7	1
Mining and energy	1	1			7	1
Total centres (67)	**10**	**11**	**6**	**4**	**24**	**12***

Note: * Nine additional centres expired early in the research period and could not be investigated. A further five centres were not being refunded and consequently expired, but at the time staff were available to participate in the research.

The largest group comprises centres with no connections to the VET sector. Over one-third of centres were in this category and many have a narrow industry focus with much of their research being directed toward commercial outcomes designed to give core partners a competitive advantage. Consequently, their research findings may be considered commercially sensitive or 'in confidence' and therefore not open to public access. Nevertheless, many of these centres have research programs aligned to VET training, thus placing them in the 'should be' category.

As shown in table 6, the 'should be' category accounts for 16 of the 24 centres without VET connections. The centres in this group are spread across all industry sectors except manufacturing technology. The lack of connections in all but manufacturing is perhaps indicative of a continuing perception of the VET sector as 'the tech', with a historical focus on 'blue collar' occupations.

Only four centres are identified in the 'nascent 'category; that is, interested in becoming involved with VET, but without any previous connection. Two of these were in the environmental industry—still a relatively new area for VET training.

Centres in the 'not relevant' category are indicative of the kind of research that is well removed from VET practice. The areas of mining and energy, and particularly medical science and technology, are strongly represented in this category. The co-operative research centres in these fields tend to perform research to produce outputs likely to have a greater impact on professional than para-professional occupations.

In addition, 12 centres in the initial group had expired or they had closed during the period of our research. Therefore, by the time the telephone interviews were begun, there were no staff to interview. The implication for the

VET sector in attempting to establish long-term relationships with co-operative research centres, is understanding that the centres have a finite life which largely depends upon their success in commercialising technology or benefiting industry and society through their work. However, what is important in this context is a recognition that centre staff move between centres and research and development programs (in the same way that VET sector staff move between organisations). Consequently, establishing long-term connections with outstanding research and development people, wherever located, will eventually pay dividends for the VET sector. In general, however, the contribution and/or participation of VET providers is most appropriately utilised when the centre is close to commercialisation of a technology product or process.

Table 6: Co-operative research centres without connections to VET by industry sectors

Industry sector	Nascent	Should be	Not relevant
Agriculture and rural-based manufacturing		4	
Environment	2	2	1
Information and communication technologies	1	3	
Mining and energy		4	3
Manufacturing	1		
Medical science and technology		3	4
Total	**4**	**16**	**8**

Co-operative research centre spin-off companies

Several co-operative research centres have established companies to house and market the outcomes of their work. The research team investigated companies created by the Australian Photonics Centre and the Centre for Molecular Engineering Technology, principally to obtain further information about skill needs and training practices in high-technology areas. However, here also we found varied connections with vocational education and training and a lack of knowledge about the VET system and how it might assist the companies to meet their skill needs. Overall, they appeared to know little about the sector, its funding sources, sources of funding that might be available to them as a result of collaboration with the VET sector, or the mechanisms available to enable them to articulate their skill and training needs. Based on this, the companies displayed a tendency to assume that the VET system would not be able to help them to meet their needs.

Lack of connections: Should we be concerned?

Are the generally weak or poor connections between co-operative research centres and vocational education and training a cause for concern? We believe so for a number of reasons.

Firstly, the lack of connections means that there is no systematic process to ensure that new knowledge created in the research centres flows into vocational education and training. It would appear that the flow of information to the sector relies largely on interested, keen and active individuals and the social and professional networks of which they are a part. This means that it tends to be indirect and ad hoc. As a result, many VET planners may be unaware of research and development in the co-operative research centres and industry-based research and development, which has the potential to lead to innovations which, if adopted, might affect the range of skills required by existing industries or lead to the creation of new industries with distinct skill needs. Therefore vital knowledge is denied to those who plan existing and future TAFE courses in response to industry needs. In addition, VET teachers might remain ignorant of developments with the potential to cause substantial change in their field; for example, through the introduction of new tools, systems or processes. Their knowledge might become outdated and their skills obsolete.

Secondly, our case studies of ten centres (as indicated in table 3) found that where the links with vocational education and training are strongest, benefits flow to both sides. For the centres, connections with the VET sector provide access to new networks and extensive experience in working with industry. As new skill needs arise, they can be accommodated more rapidly and effectively. VET links can also bring in specialist expertise and enable access to specialised equipment and other facilities. For VET organisations, benefits accruing from a relationship with a centre include additional opportunities for staff personal and professional development through participation in research and development, or in the centre's education and training program. The VET organisation will gain access to the new knowledge necessary to ensure that its teaching remains up to date; it will have information to enable it to identify new opportunities for fee-for-service provision.

Thirdly, small global high-technology companies depend on being able to recruit people who have a broad range of skills and knowledge. However, those companies appear unaware of what the VET system can offer and the capabilities of VET graduates. As a consequence, there is a tendency for them to assume, incorrectly, that the system will be unable to meet their needs. This is the case even though there is clearly a strong demand and role for vocational education and training in the establishment and development of these new high-technology industries. For instance, our research found that training provided by the VET system is implicated in both generic and specific skills including:

- technical skills in photonics and biomedical/diagnostic areas
- electrical and mechanical engineering
- production and manufacturing
- project, financial and team based management
- recruitment and human resources

- quality assurance
- sales and marketing
- occupational, environmental health and safety.

Fourthly, the lack of relationships between the sector and research centres means that the substantial potential for vocational education and training to contribute to efficient and effective 'technology transfer' in Australia remains largely untapped. Economic success is increasingly being determined by the ability to innovate—to generate ideas and to transform them into commercial market commodities (Dodgson & Bessant 1996). Embedded within an innovation capability is the necessity for transferring an idea or technology from its source of creation, often in industry or university research (for example, a co-operative research centre), to the end user. This is the process which is often referred to as 'technology transfer'—the process of conveying the 'knowledge about technology and its use, from one party to another' (Dodgson & Bessant 1996, p.12).

In the technology transfer process, vocational education and training, as a key player in industry workforce training, is arguably in a unique position to connect with the research and development sector to enable the timely introduction of new skills and knowledge which both supports the introduction of new processes and the use of new products. Thurow (1992) notes this connection, arguing that 'skilled labour will be the arms and legs that allow one to employ the new product and process technologies that are being generated' (p.51). Moreover, Teubel et al. (1996) argue that 'the transfer and transformation of existing and new knowledge, mak[es] the stock of knowledge more socially useful … exploit[ing] existing knowledge and facilitat[ing] the accessibility of the stock of knowledge' (Teubal et al. [1996] cited in Marceau et al. [1997] pp.4–15). Placing VET in the innovation value chain to support the creation of knowledge and its deployment will arguably result in a more highly skilled labour force and an increased productive industry capacity.

However, despite the logic of this argument, the VET sector is not an integral player in the commercialisation, dissemination and education and training programs undertaken by co-operative research centres. One could argue therefore, that VET is the missing link in the National Innovation System. This is most unfortunate because it has the potential to provide a sophisticated and nationally structured mechanism for the rapid introduction of new products, new knowledge and innovative practices into Australian industry.

Conclusions

Continual economic renewal through innovation has become imperative in the new millennium, which is marked by strong global competitiveness. However, investment in research and development in Australia will be wasted unless

systems, which are designed to disseminate information on innovations originating in this country, are improved. To accomplish this requires substantial investment in education and training to ensure that people have the skills required for working with the new systems, tools and processes generated by the innovation process.

Australia's National Innovation System has demonstrated significant success in generating new ideas and in their subsequent transformation into new products and applications. However, it must do better and recognise the substantial contribution that the national VET system could make in disseminating the outcomes of its work. At the same time, the VET system must become more pre-emptive in anticipating changing skill needs to ensure their being met in a more timely fashion, and must be more confident in its capacity to contribute to the national innovation effort.

To begin this process, the establishment of better links between the co-operative research centres and the VET sector is imperative. Most centres are working towards the improvement of products and processes for existing industries, but there is also some potential for new industries to emerge from their ideas and their research and development. The work of the overwhelming majority of centres is creating, or will probably create in the future, needs for some new skills or different skills that could be addressed by the VET system.

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Training needs of innovative companies

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This chapter is based on *Training needs of emerging industries*,[1] for which the researchers prepared detailed case studies of 17 small-to-medium-sized companies engaged in technological innovation in emerging industries. It examines the skill sets required by these companies and their consequent training needs, and the resulting implications for vocational education and training (VET). Although the training needs of the companies in emerging industries did not differ substantially from companies operating in traditional areas of business, some important differences were identified. It was evident that companies in emerging industries progressed through four stages of development, whereby personnel and training requirements differed in each. In the early stages, innovative companies tended to buy in personnel who possessed the highly specialised skills and knowledge required. As the companies shifted from experimentation and development to production and marketing, their workforce grew and their training needs became more conventional. Companies engaged in innovation were often working with technology in advance of that taught by VET providers, therefore their training needs differed. It was concluded that collaborative approaches between innovative companies and training providers might be mutually beneficial. Companies could benefit by receiving customised training, and VET staff could have the opportunity to upgrade the currency of their knowledge.

Introduction

THE NATIONAL STRATEGY for vocational education and training, *Shaping our future: Australia's national strategy for vocational education and training 2004–2010*, indicated that training providers need to collaborate with

[1] Misko, J & Saunders, J (2004), *Training needs of emerging industries*, NCVER, Adelaide.

industry to promote innovation in the workplace (ANTA 2003). This strategy is part of the wider drive to develop a strong economic and social future for Australia through innovation, as outlined in the Australian Government's innovation statement, *Backing Australia's ability* (Commonwealth of Australia 2003).

This chapter examines the training needs of small-to-medium-sized businesses identified as companies engaged in innovation in emerging industries. It is based on detailed case studies of 18 companies, which were analysed in the report entitled *Training needs of emerging industries* (Misko & Saunders 2004). It examines the skill sets and training requirements identified by the companies in emerging industries, and highlights the training issues faced by such companies. This information is used to examine the implications and directions for vocational education and training in developing partnerships with small and medium-sized businesses involved in innovation in emerging industries.

Defining emerging industries

The term 'emerging' implies something new and developing. Emerging industries can include new industries or segments of an industry in which new products or services are being developed for customers, or in which new or existing technologies are being developed and applied in new ways. The identification of an emerging industry is not always straightforward, one difficulty being that all industries have the potential to develop innovative methods for doing things or altering traditional methods to take account of new developments in knowledge and technology.

Project methodology

Case studies of 17 companies in which new technologies were being developed and applied were undertaken to examine the training needs of emerging industries. The focus was on industries concerned with the implementation of innovation in technology since the levels and extent of training within such companies were expected to be the highest.

The 17 companies identified were involved in developing or manufacturing leading-edge processes and products. Company sizes varied from four employees to 110 employees, with most being in the range of ten to 30 employees. Table 1 displays a list of participant companies, indicating industry sectors, and area of manufacture or service. Companies were given fictitious names to preserve confidentiality.

Table 1: Participating companies, industry sector, and nature of endeavour

Company	Industry sector	Technology used, goods produced, services provided
AeroEngCo.	Aeronautical engineering	Medium-size aircraft manufacture
AgEquipCo.	Agricultural and mechanical engineering	Agricultural spraying machinery
StrainGaugeCo.	Aviation and mechanical engineering	Diagnostic strain devices
ElectroChargeCo.	Electrical engineering	Electrical storage devices
SecuritySoftCo.	Electronics and information technology	Security software
FibreOpticCo.	Electronics and telecommunications	Fibre optics
SunPowerCo.	Energy	Solar power pumps and water treatments
EnergyCellCo.	Energy	Energy generation
ToolingCo.	Engineering	Manufacturing dies and machine tools
CellGrowCo.	Health, medical research	Growth of cell tissues
CompuHealthCo.	Health, medical research	Medical diagnostic tools
FinishesCo.	Materials engineering	Metal treatments to surfaces
AlloyCo.	Materials engineering and manufacturing	Titanium products manufacture
FanTechCo.	Mechanical engineering	Fluid and fan technology
EarCo.	Medical technology, health and electronics	Hearing enhancement appliances
ScanningCo.	Medical technology and health	Medical scanning devices
CallingCo.	Communications	Speech recognition appliances

Information collected through structured telephone interviews included the company's business activity, recruitment and selection procedures, staff qualifications, staff training, and skill and training requirements for the future.

Evolving stages of development

Four stages of development were identified as the companies progressed from small organisations researching and developing a concept, to mature companies engaged in manufacturing and marketing their products. Each of these stages had different personnel and training requirements.

Initial research and development

In the first stage, the company often comprised a few employees working almost exclusively on researching and developing a concept. These individuals usually included the originators of the idea and a few highly qualified or experienced specialist personnel, such as mechanical engineers, physicists, chemists and highly experienced tradespeople. During this stage, the company often 'bought in' personnel, who possessed specialised qualifications, expertise and experience, rather than engage in training.

Development and testing of the concept

As the idea progressed further, more people were employed to develop and refine processes and build and test prototypes. These new employees were generally experts in their fields and often had practically oriented qualifications and experience, such as tradespeople.

Initial production and marketing

In the third stage, the company embarked on manufacture and sale of its products. In order to achieve this new purpose, new personnel with the basic qualifications for the job were employed. The company then taught these new employees the specialised skills and knowledge they required, as these skills were often not available from external training organisations. At this point in development, the company also commenced hiring a new component of its workforce—less skilled employees. These employees were involved in the more routine processes of production, administration and clerical support. Personnel originally involved in the establishment of the company were often involved in sales and marketing. Alternatively, sales and marketing personnel were employed.

Major production, marketing and sales

In the fourth stage, the company was substantially engaged in production, marketing and sales. Less skilled personnel were required for production, supply and distribution functions. Qualified and experienced personnel were required to take care of marketing, sales, finance and quality control. Personnel were also, on occasions, required for management and human resource functions. Research and development generally continued, but as a smaller proportion of the company's overall operations.

Skills, knowledge and attributes

As was previously mentioned, the workforce of a new company concerned with development of innovation/s often comprises a small group who share ideas and combine resources to solve the problems encountered in developing a new idea. Therefore, in choosing employees to work in such an environment, employers particularly sought people with suitable values, attitudes, and dispositions.

The innovative companies sought to recruit highly skilled, qualified and experienced personnel for research and development, technical, financial, and managerial functions. Where formal qualifications were not the main criterion for employment, they, like any other company, looked for people with relevant skills and proven experience.

There was an expectation that employees in the higher-level knowledge occupations (for example, researchers, scientists, engineers, metallurgists, audiologists, technicians, accountants, and marketers) would already have the highly developed fundamental skills and knowledge required for their occupations. The company would then build on these skills and knowledge to develop highly specialised expertise, and customise work roles and processes to company requirements.

The type of work carried out by clerical and general support workers in innovative and emerging companies was very similar to that of companies operating in traditional business areas. However, the focus for those involved in management, research and development, technical operations, marketing, sales, and accounting, was often more specialised. The companies were typically heavily dependent on the accurate targeting of niche markets at home and abroad. Consequently, the companies required knowledge of how to protect intellectual property in an extremely competitive international environment. The international focus of many of the companies required particular employees to be familiar with the appropriate foreign language and to possess an understanding of the culture of the people with whom they were dealing. There was also an increasing need for accountants and directors to understand legal issues, including those relating to statutory declarations and intellectual property. Table 2 summarises the skills and knowledge reported by respondents for the different occupational categories.

Training needs

Companies in emerging industries indicated that training needs often differed, depending on the role of the employee in the organisation. As the companies were often involved in advanced technology, they also often had unique training needs.

Training needs for the differing occupations

The bachelor degree and higher degree level qualifications often sought by innovative companies for their research and development, technical, marketing, and managerial functions were generally available from institutions of higher education. However, companies in emerging industries also required courses which developed the knowledge and skills of employees working in trades and other technical roles, clerical and administration functions, and manufacturing and production.

Table 2: Skills, knowledge and experience required, by occupational category

Skill/knowledge/experience	Managers	R&D	Technicians	Financial	Sales	Clerical	Production	Corporate
Relevant qualifications and experience	◆	◆	◆	◆	◆			
Supervisory skills	◆	◆						
People skills	◆				◆			
Problem-solving skills	◆	◆	◆					
Negotiation skills	◆				◆			
Market knowledge	◆			◆	◆			
Occupational health and safety	◆		◆					
Quality assurance	◆	◆	◆	◆	◆	◆	◆	◆
Financial skills and knowledge	◆	◆		◆	◆			
Computer skills	◆	◆	◆	◆	◆	◆		
Relevant specialised software expertise	◆	◆	◆	◆				
Mechanical skills			◆					
Technical skills for job (process and trade skills)			◆[1]					◆
Report writing	◆	◆	◆					◆
Project management	◆	◆	◆					◆
Planning skills	◆	◆		◆	◆			◆
Public relations skills	◆	◆	◆	◆	◆			◆
Intellectual property	◆	◆		◆	◆			◆
Business administration skills	◆	◆						◆
Marketing and entrepreneurship	◆	◆	◆		◆			
Decision-making skills	◆	◆	◆					
Time management	◆							
Product knowledge	◆				◆			◆
Language, cultural understanding	◆				◆			
Bookkeeping skills						◆		
Telephone skills						◆		
Knowledge of company field (science, etc.)					◆			◆

Note: [1] Take instructions, follow design drawings, testing techniques, CAD-CAM, CNC, electrical, electronics, laboratory techniques, fitting and turning, telephony, C++.

Companies in emerging industries required more specialised training in the following areas:

- ❖ human resource management
- ❖ computer operation
- ❖ industry-specific and generic computer software packages (such as computer-aided design, word processing and spreadsheets)
- ❖ computer programming

- project management
- report writing
- marketing
- team building
- language and culture
- time management
- quality assurance.

These types of courses were already available in many VET institutions. Alternatively, courses could be developed by providers who had experience in working with enterprises to customise training for specific needs.

Identifying unique training needs and difficulties

Case study respondents identified a range of training needs that were particularly important to companies operating at the leading edge of their field in emerging industries.

One of the most substantial obstacles faced by innovative companies was the lack of training available for people working at the leading edge of technology, or for those working in small, highly specialised sectors of industry. One company working in a specialised sector of the electrical industry found it impossible to obtain specialist and 'state of the art' training for its employees. This company had to employ people with high-level underpinning knowledge and skills and then provide them with specialised in-house training. Many of the case study companies employed this solution. These companies also typically accepted that it was unrealistic to expect such specialised training to be available 'off the shelf'.

Highly specialised and leading edge technology training not available

Even when the company recruits an employee with an aircraft maintenance engineer's qualification, it cannot put them to work without on-job training. The type of work [our company] undertakes does not exist anywhere else in Australia. In-house training is necessary.

… I don't believe there is a recognised course available for aircraft draughtspersons. Essentially you find someone who can draw, and if they haven't worked in the aircraft industry, you have to train them. We have just put on a young fellow as a trainee draughtsman who is very good at CAD [computer aided design] but knows nothing about aeroplanes.

AeroEngCo

A number of case study companies also engaged in cooperative training ventures with an established registered training organisation or training provider who was registered to deliver accredited training under the Australian Qualifications Framework. In such arrangements, the provider and the company jointly customised existing training or developed new training. The provider often delivered the training at the business location of the company. For example, an aircraft manufacturing company was establishing a training schedule in which the trainers would conduct formal training at the site for a full week at the beginning of each month. Qualified assessors, supplied by the provider, conducted the assessments. The alternative was companies sending their employees off-site to access formal training. In some cases, employees were sent overseas when training was not available in Australia. However, if there were a number of employees who required training, then the company would arrange for the offshore trainer to come to Australia.

Many of the companies indicated a need for employees to understand the issues relating to competition and entrepreneurship. Therefore the companies placed a high priority on training in the areas of commerce and business. Topics particularly important within these areas included general commercial skills, developing quotations for goods, protection of intellectual property, drawing up contracts, developing and managing distribution networks, marketing, sales, and project management. As was previously mentioned, this training often needed to encompass the international environment, a situation which, on occasions, prompted some companies to seek training in language and cultural awareness relevant to the countries they were dealing with.

As the companies were often heavily engaged in research and development, training in research methods and report writing were particularly important. These skills were required to enable the companies to establish credibility as part of the process of having their new ideas and products accepted.

Implications for VET

The findings from the case studies led to the identification of important implications and directions for vocational education and training in the area of emerging industries. In specific terms, where the work skills required by innovative companies are similar to those required by traditional companies, the VET sector can provide the courses. There is also a need to develop the skills unique to emerging industries.

Similar VET requirements to other companies—but with some important differences

At face value, the skills, knowledge and attributes identified for innovative companies are very similar to those required by other companies. To be

successful, whether operating in emerging fields or in more traditional business areas, companies require adequate managerial, technical, financial and commercial expertise, together with quality assurance and occupational health and safety mechanisms.

Like companies operating in traditional business areas, the innovative companies sought managers with knowledge of the business, and with the managerial and supervisory skills to provide leadership in the development and production of goods, and delivery of services. What differentiated the case study companies from others were their innovative products and services.

These companies also require skills unique to working in the global market, including an understanding of foreign languages, cultures and niche markets. In addition, they require skills relating to legal issues, including international law and standards, and the protection of intellectual property.

Directions for vocational education and training in emerging industries

A large proportion of the skills, knowledge and experience identified by these companies can be provided by the VET sector.

Emerging industry companies have many of the same general educational requirements as other technology-oriented companies. The VET sector already provides courses to develop the knowledge and skills of employees working in trades and other technical roles, clerical and administration functions, and manufacturing and production. The sector is also experienced in providing the more specialised training required in areas like human resource management, computer operation, use of industry-specific and generic computer software packages, computer programming, project management, report writing, marketing, team building, language and culture, time management, and quality assurance.

Customisation, and where feasible, development of new courses, can play an important role in helping emerging industry companies acquire the highly specialised skills needed to operate at the leading edge of technology, access venture capital, and enter and compete in global markets. Areas of importance in this context include protection of intellectual property, application of patent law, and commercial and marketing expertise. It can also include skills for negotiating contracts in different cultures.

Vendor training was identified in the report as one of the best ways for companies to access the most up-to-date training. This refers to training provided by the vendors of equipment and materials. The VET sector and vendor providers may be able to gain mutual benefit if they worked cooperatively in providing training. VET staff can gain knowledge of the latest technology and product development, and vendors can gain access to VET expertise. For example, vendor trainers could undertake VET 'train-the-trainer'

courses. Company facilities can be established to assist VET providers to provide specialised training to workers on site.

Finally, in working with emerging industry companies, the VET sector must recognise that company training needs change as they move from research and development to manufacturing and trading. During the early stages of development these companies often comprised a small number of workers who were highly knowledgeable in specific areas and possessed high-order technological expertise. However, they can lack relevant knowledge of manufacturing design technology, of strategies for the protection of intellectual property, of patent law, and of procedures for raising and managing capital. Towards the end of their development cycle, the focus of the companies will often have moved to processes required for the manufacturing, packaging and selling of products. This necessitates knowledge and skills in production management, human resource management for a larger and more diverse workforce, and promotion and marketing of goods.

Conclusions

Companies engaged in technological innovation or in the development of new ideas have diverse and important training needs. While much of the higher-level training and the majority of the qualifications required are generally provided by higher education, the VET sector also has a role to play in developing further knowledge and skills subsequent to the hiring of experienced and qualified personnel. Because these innovative companies are often operating at the leading edge of their technological fields, the further training they require can be highly specialised and sometimes unique. VET providers are already well placed to provide customised training for employers. However, these companies may provide VET staff with the opportunity to advance the currency of their knowledge. This can be achieved by VET providers working closely with the companies to identify special requirements, developing programs to deliver the special training, and extending the expertise and knowledge of its teaching staff.

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Stimulating the demand for skills within skillecosystems

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Confronted by skill shortages, the growing casualisation of work, and persistent under-employment and unemployment, many governments in advanced industrialised economies are reviewing their education and training policies and reconsidering the role of the state within training markets. In Australia, significant and ongoing changes to the nature and content of work have polarised the labour market with high-wage, high-skill, permanent and full-time work on one hand, contrasted with low-skill, low-wage, casualised and precarious employment on the other. There is now a strong case for reviewing current skills policy, and particularly the current supply-side focus, to ensure that governments have a range of policy instruments to maintain and stimulate economic and social development.

The New South Wales Department of Education and Training is leading a national project funded by the Australian National Training Authority (ANTA) to reposition skills policy within the broad matrix of economic and labour market policy. Critical to this is the development of a new skills policy framework—skillecosystems—to reflect and respond to the modern and dynamic economy and society. Skillecosystems represent an evolution in our policy thinking. They recognise that skills and jobs are intertwined and are defined by the specific configuration of firms, products, markets and the public policies that surround them. This interdependence requires policy-makers to extend the focus of skills policy beyond the supply of skills to a consideration of those factors which affect the demand for and use of skills, factors such as labour market settings, firms' competitive strategies, the changing nature and content of work, and broader economic policies.

Divining patterns within the changing environment

ANTA HAS RECENTLY confirmed a new national vocational education and training (VET) strategy, *Shaping our future* (ANTA 2003), setting out the broad direction of skills policy to 2010. This new strategy includes a number of objectives for skills policy (such as employment, regional

development and innovation), which are both new and which represent a significant evolution of the VET system. They reflect a broadening of thinking, a reconceptualisation of vocational education and training as more than simply an education sector, '… but as an economic and social force that has a role along side other parts of the social and economic infrastructure in building social capital[1] and shaping economic and social outcomes both regionally and nationally' (Phillips Curran 2002, p.7). Meeting these new objectives requires the development of new solutions, not merely modifications to existing policy, and will depend upon greater integration of skills policy with broader economic and social development policies.

It is timely therefore to think about what VET policy can and ought to be achieving against this backdrop of change, and to consider the current mix and focus of policy. We must acknowledge that the achievement of the challenges set out in *Shaping our future* cannot be solved by skills policy alone. Simply increasing the quality and the quantity of skills, regardless of what those skills are, will not by itself create more or better employment or lead to economic growth. The challenge is broader, and it requires the creation of an economy which *demands and utilises* significantly greater skills—not just for professionals or elites, but for the broad middle of Australia.

In this endeavour, Australia is in the company of a number of other nations (see particularly Ministry of Manpower [Singapore] 2000; Cabinet Office Strategy Unit 2001, 2002; International Labour Organisation 2002; Human Resources Development Canada, 2004; Department of Labour [NZ] 2004). All are similarly grappling with the challenge of increasing sustainable, high-wage employment and national competitiveness within a context where the dominant economic forces today—globalisation, technological change, quixotic consumer choice, borderless capital markets and short-term investment horizons—have neither a uniform nor universal impact on nations, firms, communities or individuals. Australia's situation is, however, further exacerbated by the fact that the economy is heavily reliant on casual and part-time workers—workers only marginally involved in training (Wooden 2001; Hall, Buchanan & Considine 2002).

Despite our best efforts, our current skills policy framework is not fully oriented to the complex work of the twenty-first century, as is evident by the persistence of skill shortages in key industries, increased casual and contingent employment, the collapse of traditionally strong internal labour markets, and considerable work intensification (Australian Centre for Industrial Relations Research and Training 2003). As stated in ANTA's *National industry skills report*:

> *… the more structured society of the 20th century is being replaced by one where networks, relationships, knowledge and integration will be key features of*

[1] Social capital is the accumulative benefit accruing to individuals and communities as a result of their engagement in community and civic activities and the consequent networks established.

> *success, both economically and socially. The way we work will fundamentally change. The context within which learners learn and enterprises skill their workers will also change.* (ANTA 2004, p.2)

Changing nature and content of work—reaching the limits of conventional skills policy

Where is this complex twenty-first century work? While the information and communication technology revolution has created some high-paid jobs, and enriched many others, it has also stripped skills from countless others or eliminated them entirely. For example, the same market forces which drive the demand for more financial planners, for highly customised retirement products, and for online banking, displace the jobs of data-entry clerks, bank tellers and possibly even bank managers.

As Mark Cully writes in the *Australian Bulletin of Labour*:

> *History has shown us often enough that the consequences of technical change for work are likely to be ambiguous. While the amount of knowledge embedded in production and service delivery has increased, the net effect on workers cannot be predicted on* a priori *grounds. If the knowledge content of a particular task has been codified as, say, a piece of software, it is not at all obvious that the application of this software represents an increase in the knowledge required to undertake the work.* (Cully 2002, p.142)

British knowledge economy sceptics argue that high-skill industries will only ever create a limited number of high-skill jobs, and that low-skill, and possibly low-wage jobs, will constitute the majority of all employment. These sceptics point to the service industries, particularly retail and hospitality, where the majority of firms still compete primarily on price, standard goods and services, and use predominantly low-skill, low-wage and casual workforces (Lloyd & Payne 2002). This appears true for Australia also, where employment in high-skill and innovative industries, such as in manufacturing, has declined in absolute and relative terms compared with low-skill employment, such as in retail and hospitality.

Likewise, increased competition hardly guarantees upskilling. In an environment where competitive advantage depends on the quality and cost of labour, employers can choose to make labour more productive by recruiting higher skilled workers or training existing employees, and organising the work to increase productivity through new technology and talented employees. Alternatively, they can simply reduce wages or organise work so that there are relatively few well-paid knowledge jobs and lots of lesser-paid, lower-skill work. Too many choose the latter path, adopting strategies based on low cost and low skills. This tendency has been observed in Australian firms where 'productivity and profit is [sic] achieved through work intensification and lower

pay rates, which are used as the prime means of trying to capture lower labour costs' (Hall, Buchanan & Considine 2002, p.36).

The historical focus of skills policy has been on increasing and improving the supply of skills as a means of improving individual employment prospects, economic performance, and broader social cohesion. The logic of this supply-side consensus is that, by increasing and improving the supply of skills, firms will have the fuel to shift from low-skill to high-skill production, from commodities to value-added goods and services, and from casual and contingent labour, to permanent staff. Although some have argued that too much has been expected of skills policy, there is little doubt that, under ANTA's stewardship, Australia is in a much more competitive position as a result of the last ten years.

This being the case, two points must be made. Firstly, we now have the most educationally qualified workforce in history—including the unemployed population—where nearly 40% of Australians with trade qualifications, more than 20% with bachelor's degrees, and 12% with postgraduate qualifications, are in jobs that require no qualifications at all (Considine 2000, p.5). Secondly, there are limits to what can be achieved through supply-side strategies only. This second point was forcefully made by the British academic, Dr Ewart Keep, in the *Journal of Education and Work*, in a critique of the focus of the Learning and Skills Council in the United Kingdom:

> *… there remains the LSC's lack of any capacity to intervene to boost employers demand for skills. Its main weapons here are exhortation, dissemination of good practice, and the provision of more information about the benefits of training (to both individuals and employers). In other words, the strategy is based on the standard belief that the root of our skills 'problem' lies with a simple case of market failure. Economic theory suggests that the best remedy is to supply all the actors with better information and, hey presto, the magic of the market will reassert itself as levels of investment by firms and individuals leap upwards.*
>
> (Keep 2002, p.467)

Perhaps, rather than having a skill–supply problem—a problem where firms' competitiveness is constrained by a limited supply of skills—the problem might better understood as a demand-side problem, in which firms' product markets, work organisation, and job design produce only weak demand for and use of skills. Case studies in both manufacturing and the service sector in the United Kingdom have identified and described this phenomenon as a low-skill equilibrium, and concluded that: '… the limits of what can be achieved by skills supply interventions are being reached' (Department of Trade and Industry [UK] 2003, p.xvi). It is more likely that the Australian challenge is a combination of the two, and requires the development of sophisticated policy solutions which combine improvements in the supply of skills with labour market interventions and innovative industry policy, to encourage firms into developing new products for new markets. It is this view which underpins the ANTA national skillecosystem project being led by the New South Wales Department of Education and Training.

Skillecosystems—reconciling supply with demand

The goal of the ANTA national skillecosystem project is a repositioning of skills policy, and specifically, the development and exploration of new roles for VET providers within specific skillecosystems. As stated in *Beyond flexibility*:

> *While 'VET', as an area of government activity, is located within particular bureaucratic or ministerial boundaries, its core business is skills formation, and skills formation is not and can never be a stand-alone issue. By itself, skills formation is not a solution to Australia's global competitiveness nor to growing inequality. So long as VET is considered this way, VET will fall short of the expectations placed upon it.* (Buchanan et al 2001, p.27)

Skillecosystems are interdependent clusters of skills within regions and/or industries which are shaped by the nature of firms and networks of firms, the nature of products and services and production processes. They are also shaped by markets and market regulations, and by key institutional and policy settings, including employer and employee associations, VET providers, and regulatory authorities.

By way of an example, the Australian wine industry skillecosystem relies on the full spectrum of skills to produce, market and distribute its products: high-end skills in advanced bio-technology and viticulture; intermediate skills such as resource management and retail; and lower-end skills such as transport, harvesting and bottling. The industry is focused on both domestic and global markets, with approximately 40% of Australia's wine sold abroad (Australian Wine and Brandy Corporation 2002, Australian Wine Online 2003). Demand for and use of skills across the entire skillecosystem is best understood as a function of both external and macro-settings, such as economic and trade policy and labour market regulation, and internal and micro-settings, such as the seasonal nature of the industry, environmental regulation and harvest management. Changes to any one or more of these factors, such as significant climate change, advances in research and development, or even increased demand for seasonal labour from competing horticultural employers, flow through the industry supply chain and affect regional production levels and techniques, firms' competitive strategies, the specific products being produced and, ultimately, the aggregate demand for work and skills.

Using the skillecosystem framework to analyse regions or industries, such as the wine industry, reveals how the unique configuration of firms, institutions, markets and regulations affects the demand for and use of skills and enables policy-makers to reconcile these demand-side drivers with traditional supply-side considerations.

The skillecosystem project consists of five separate but related streams of activity. They are:

- ❖ funding state and territory ANTA Innovation Plan projects involving VET providers working with new and emerging industries

- commissioning a series of demonstration projects to explore and develop the role of VET providers
- establishing a website, <http://www.skillecosystem.net>, including an electronic news service and an online forum
- leading a high-level peer network to identify, develop and disseminate information about emerging challenges and opportunities for vocational education and training
- a diffusion strategy focusing on VET leaders and practitioners.

Phase one of the project is largely complete. Two progress reports are available online at <http://www.skillecosystem.net/news/> which provide significant detail on the funding of state and territory ANTA Innovation Plan projects, demonstration project progress and the development of a comprehensive communications strategy. Phase two, which will involve commissioning further demonstration projects and implementing a diffusion strategy, will be completed in late 2005.

Demonstrating the role of VET providers as innovation agents

A critical component of the ANTA national skillecosystem project is a series of demonstration projects designed to test and develop the capacity of VET providers to increase the demand for and use of skills within specific skillecosystems. Three demonstration projects were commissioned in 2003, two of which are focused on developing the role of VET providers as innovation agents engaged in the creation, diffusion, and commercialisation of new knowledge and skills.

A clear theme running through international economic development literature and policy is the importance of innovation to a nation's economic performance. Innovation, variously defined, is undoubtedly a critical driver of Australia's economic performance and a major factor determining firms' changing skill requirements. However, to date, the role of the VET sector has been largely overlooked; programs like *Backing Australia's ability* (Commonwealth Government 2001, 2003) prefering instead to focus on higher education and on initiatives to increase the number of science and engineering graduates and fund more 'blue skies' research.

Innovation is not an entirely random process. It can be affected, promoted and managed through a combination of specific policies supported by a range of institutions, including education and training providers. Research by the Australian Expert Group on Industry Studies identifies roles for VET providers within a broad range of mutually reinforcing policies and arrangements designed to support innovation and innovative firms (Marceau 2001; Australian

Expert Group on Industry Studies 2001, 2003; Toner et al. 2004). These studies stress the need for national systems, for collaboration between firms, and for the focus of policy to cover networks of firms, rather than individual or even leading firms, and advocate the development of regional and/or industry 'action agendas'. Action agendas are mechanisms which bring government and industry together to collectively plan for improving the competitiveness of networks of firms.

> *Each Action Agenda has varied somewhat its methods of work but commonly includes research into the basic parameters of the industry. The parameters include technological capability, skills levels, and R&D infrastructure and the trade and industry structure (number and size of firms etc.) of the areas as well as its productivity.* (Marceau 2001, p.12)

In related research by the National Centre for Vocational Education Research (NCVER), the focus has been on how VET providers can improve the diffusion of innovation by collaboration with co-operative research centres, and also on the impact of innovation on jobs and skills. Although the report, *Going boldly: A VET journey into the national innovation system* (Ferrier, Trood & Whittingham 2003) finds generally weak links between the co-operative research centres and the VET sector, it concludes that the latter has both the capacity and networks to engage across the full spectrum of the '… knowledge creation process as well as in the [co-operative research centres'] commercialisation and dissemination and education and training programs' (Ferrier, Trood & Whittingham 2003, p.92).

Based on this research, the 'innovation agent model' was developed as a practical test of the capacity of the VET sector to inform the development of new policies and programs. Importantly, the innovation agent model does not assume that innovation will uniformly result in increased demand for or use of skills, and both demonstration projects are focused on managing the risk that innovation may displace skills and employment.

United Water and the Water Innovation Network

The first of the two innovation agent demonstration projects is primarily intended as an exploration of the Australian Expert Group on Industry Studies 'action agenda' model within the South Australian water skillecosystem.

United Water, Australia's largest private water company, is leading the Water Innovation Network consortium involving TAFE South Australia through the Torrens Valley Institute, and AITEC Corporate Education and Training. United Water has a 15-year contract to operate and maintain the water and wastewater systems in metropolitan Adelaide. As part of this contract, United Water has made a commitment to lead the development of an export-oriented water industry based in South Australia. Specifically, United Water will use its international networks to improve access to export markets for South Australian companies and will lead the development of new technologies. The United Water–Water Innovation Network demonstration project leverages this

commitment to develop the capacity of TAFE South Australia through Torrens Valley Institute as an innovation agent.

The United Water–Water Innovation Network demonstration project is simultaneously developing linkages between the VET community, and the research and innovation communities, as well as addressing barriers to technology transfer experienced by small-to-medium enterprises.

TAFE South Australia, and the South Australian VET sector more generally, has historically strong links with the South Australian water industry, particularly from manufacturing through to maintenance. However, only weak links exist between the VET sector, and the research and develoment community. Addressing this weakness has been the initial focus of the demonstration project and has involved establishing relationships with relevant research and development organisations and mapping the full range of research activities against TAFE South Australia's capabilities.

The United Water–Water Innovation Network is leading a series of workshops with end-users—small-to-medium growers, service providers, as well as irrigation trusts, regulators and large industry—to assess the impediments to and impacts of improved innovation and technology transfer. End-users identify several impediments, including limited independent and impartial *general* information, a lack of understanding of the specific business applications of new technology, and a concern about the capacity of existing staff and service providers to provide technical and maintenance support. In response, Torrens Valley Institute is developing a diffusion strategy which leverages existing networks and builds on the improved links with the research and development communities.

Although not originally part of the demonstration project, the recent formation of the International Centre of Excellence in Water Management in Adelaide is linked to the United Water–Water Innovation Network demonstration project. Through its involvement in the project, TAFE South Australia was invited to join the Water Australia Group (a consortium of universities, the Commonwealth Science and Industrial Research Organisation, key water research centres, South Australian Government agencies and key industry partners) which successfully bid for Commonwealth funds to form the International Centre of Excellence in Water Management. TAFE South Australia's involvement led directly to the extension of the initial model for the centre of excellence beyond degree and postgraduate levels to include training at Australian Qualifications Framework levels IV–VI.

Swinburne University of Technology, TAFE division

The second of the two innovation agent demonstration projects is testing the findings from *Going boldly: A VET journey into the national innovation system* (Ferrier, Trood & Whittingham 2003). Swinburne University of Technology, TAFE division, in conjunction with the Co-operative Research Centre for

Microtechnology and the MiniFab, a prototyping offshoot of the Co-operative Research Centre for Microtechnology, is leading a demonstration project to promote knowledge and take-up of microtechnology across small-to-medium manufacturing enterprises in Victoria and to increase resource-sharing and collaboration generally between technical and further education (TAFE) providers and co-operative research centres.

Rather than a discrete industry or a single technology, microtechnology combines many technologies and has potential applications across all industries. According to the Co-operative Research for Microtechnology, the global market 'is predicted to grow from its current US$42b to US$180b over the next ten years' (Co-operative Research Centre for Microtechnology 2003, p.2). Microtechnology represents a significant challenge for the VET sector as it simultaneously *converges* existing technology and skills (combining traditionally disparate fields of science, engineering and electronics within single applications) and *disrupts* existing technology and skills by replacing existing processes, products and, potentially, skill and work. Unlike more traditional industries, no single body is likely to have the competence or coverage to develop a microtechnology training package, particularly given the compressed half-life of skills and knowledge.

Various strategies have been developed and are being implemented to promote knowledge and take-up of microtechnology innovations, including a strategy to make the traditional boundaries between teaching departments more permeable. Through an industrial release program, teachers from three departments have worked directly with the MiniFab to map the knowledge and skill embedded in specific new technologies, and to support training and professional development.

Likewise, the division between teaching, research and commercialisation is being reduced. A collaborative research project involving Swinburne students working directly with the MiniFab has developed two products essential to the microtechnology manufacturing process: a 'breadboard', a device used to ensure that electronic circuitry is wired correctly before being manufactured in bulk; and a peristaltic pump controller, a device used to control the rate and direction of the flow of fluids in a test environment. Both devices, once they complete a testing phase, may be manufactured entirely by Swinburne and supplied to industry to further integrate Swinburne within the microtechnology industry.

Resource-sharing between Swinburne and the Co-operative Research Centre for Microtechnology is also a focus for the demonstration project. Swinburne's Centre for New Manufacturing and the departments of Industrial Sciences, Mechanical and Automotive Technologies, and Electrical and Electronics are working with the Co-operative Research Centre for Microtechnology and the MiniFab on resource-sharing arrangements, including training and technical expertise, as well as physical resources. In related work, Swinburne is a formal partner in the current co-operative research centre funding round and is working with both the co-operative research centres for Microtechnology and

Cast Metals on the development of an application for refunding, and also on a new bid with the Co-operative Research Centre for Organic Food Products.

Alongside strategies to integrate Swinburne in the development and dissemination of mircotechnology, the demonstration project is focused on developing market awareness of microtechnology. Swinburne has developed a 'new industry' seminar series for small-to-medium manufacturing enterprises designed to stimulate the uptake of microtechnologies. This seminar series introduces these enterprises to microtechnology, laser and robotic manufacturing, and to cleanroom technology (controlling environmental and contamination elements within specified parameters).

Conclusions

By most measures, Australia's skills policy has been successful and we can take pride in the fact that, since the creation of the 'national VET system', Australia has not had to confront large-scale, enduring skill crises or the inability to support economic growth. The VET system has nearly two million enrolments and some 375 000 apprentices and trainees in training—twice the number in training just five years ago. Hours of training likewise have exploded (NCVER 2003). Tighter connections between training providers and the market have resulted in the majority of businesses expressing satisfaction with VET graduates. We should not be surprised that vastly more university graduates enter TAFE than the other way around, or when three-quarters of TAFE students following graduation are employed compared with two-thirds of university graduates.

Nonetheless, growing numbers of economists from one perspective, and educationists from another, are beginning to identify a new model for skills formation. This model suggests that an effective relationship between skill and work requires policies which not only produce more skills, or even more responsive skill delivery, but also connect skill 'production' policies with strategies to increase demand for more and higher-level skills.

Skillecosystems are a conceptual framework for reconciling the historical supply-side focus of skills policy with broader economic and regional development initiatives by combining and leveraging existing government functions. They provide the basis for governments to work with a range of actors—firms, individuals, industry bodies, employer and employee associations—to create and support unique programs of activities which will stimulate economic and social development.

The ANTA national skillecosystem project builds on a growing body of domestic and international literature advocating a broad role for government. As Peter Noonan outlined recently:

> *The key question is whether or not Australia is poised to make the transition, from a largely standards and qualification based system, to a broader construct of*

workforce preparation, which subsumes, but goes much further than, current approaches to knowledge and skills and the means by which they are acquired.
(Noonan 2003, p.3)

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How vocational education and training providers are working innovatively with industry

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Vocational education and training (VET) enterprises are revealing a wide range of innovative responses in their efforts to work more successfully with their industry partners. In this 'report card' on how well they are performing in working innovatively with industry, the performance of these organisations is tested against nine characteristics of innovative enterprises. Innovative organisations: create learning cultures; make innovation a core capability; identify their innovators; reward people for bringing forward innovative ideas; use partnerships to bring in new knowledge to drive further innovation; have leaders who are risk-tolerant; develop teams and cross-functional teams; create communities of practice which meet regularly to discuss common interests; and provide places to be innovative.

Overall, the VET organisations which were studied are achieving remarkable outcomes for their industry partners, especially through their ability to partner successfully. Successful partnerships are going hand in hand with efforts to provide more flexible and relevant training solutions for industry. At the same time, the development of innovation in these training organisations can best be described as uneven. In many instances it is certain individuals and teams within institutions who are leading the way, rather than an organisational capability for innovation being the main driver. However, the case studies are cause for optimism about the VET industry in the longer term being a major contributor to the growth of Australia's reputation for innovation.

Introduction

AUSTRALIA HAS BECOME very serious about its intentions to be a major player in the knowledge economy. While the services sector stills drives a large part of our economy, today our national prosperity is being linked increasingly to our aspirations for creating knowledge-based industries and a knowledge-based economy which rest on the production, distribution and use of knowledge and information. If we are to meet these challenges, organisations

in a wide range of sectors will need to operate more innovatively in their response to the needs of customers and industry partners.

Innovation is described by Wolpert (2002) as 'pursuing radical new business opportunities, exploiting new or potentially disruptive technologies, and introducing change into the core concept of your business'. Innovation is concerned with the successful implementation of creative ideas within the organisation. In more recent times, the term 'innovation' is being used to refer to all creative activities occurring within an organisation. Using the findings from previous business and organisational research, this chapter first describes nine characteristics of innovative enterprises. Various examples are given of how VET organisations are demonstrating these same characteristics in responding more innovatively to the needs of their industry partners and learners. These nine characteristics of innovative organisations are:

- Innovative organisations create learning cultures.
- They make innovation a core capability.
- Innovative organisations identify their innovators.
- People are rewarded for bringing forward innovative ideas.
- They use partnerships to bring in new knowledge to drive further innovation.
- The leader's attitude about failure is a key to innovation.
- They develop teams and cross-functional teams.
- They create communities of practice which meet regularly to discuss common interests.
- Innovative enterprises provide places to be innovative.

These nine characteristics of innovative organisations have been identified from an extensive review of the academic research literature into innovation and innovative organisations (see Callan & Ashworth 2004). This report, published by the National Centre for Vocational Education Research (NCVER) provides a detailed review of this literature which has resulted in proposing these nine factors as characteristic of innovative organisations. It is not claimed that these characteristics are the only practices which appear to set innovative enterprises apart from other organisations. However, there is considerable evidence that many businesses in a variety of industries in a wide number of countries promote such practices to establish and to maintain their reputations as innovators.

Method

There are many well-documented examples already in the VET literature about how VET organisations are behaving innovatively, especially in the areas of

partnerships, networks and knowledge brokering (see Callan & Ashworth 2004; Gientzotis Consulting 2003; Mitchell et al. 2003). These innovations include developments in how training is being delivered, the involvement of industry as partners, greater levels of customisation of the training, and the introduction of skills centres. This current chapter draws considerably upon such cases, and brings them together as a 'report card' in terms of how VET enterprises are establishing a reputation as innovative partners with business. In addition, new cases are included from current research into innovative VET organisations (Callan 2004).

In this ongoing research, the author visited and talked to VET organisations specifically about how they are promoting innovation and innovative problem-solving in the context of identifying training solutions to best meet client needs. Those organisations visited in order to construct more detailed case studies were Gold Coast Institute of TAFE, Victoria University of Technology, Institute of TAFE Tasmania, and Onkaparinga Institute of TAFE. Project funding only supported a small number of case studies where actual visits could occur, and given this, it was decided, where possible, to select the major cases from across different states. Organisations were selected based upon evidence of winning awards for innovation; write-ups of achievements in innovation; and through nomination by TAFE directors from across various states. In addition, a number of smaller case studies were undertaken, largely through telephone interviews, with representatives of the Australian Institute for Care Development, Construction Training Centre, Aviation Australia, Barrier Reef Institute of TAFE, Northpoint Institute of TAFE, Australian Ikebana Centre College of Art and English, and Workplace Australia.

Findings

Innovative organisations create learning cultures

We know that more innovative organisations have an organisational motivation or a desire to innovate—a basic orientation or culture which supports creativity and innovation. They also take steps to build cultures to promote learning. Learning organisations are skilled in creating, acquiring and transforming knowledge, and in changing their behaviour to reflect this new knowledge and insights. In particular, they permit a basic organisational curiosity which promotes a desire among employees to be innovative. A true learning organisation promotes innovation by empowering its people, integrating quality initiatives with quality of work life and creating free space for learning. Such learning-focused enterprises also encourage collaboration, promote inquiry, and create continuous learning opportunities for their employees, and often with their customers and partners.

This research and case studies have shown that VET organisations are promoting innovation, in particular by encouraging staff at all levels to feel

empowered in how they develop new and different ways of meeting the training needs of employers. In its partnership with Mitsubishi, Onkaparinga Institute has established an industry-led model which has moved to a consortium arrangement between several companies in the region. This consortium supports the principle that it is a learning community, with all partners learning from one another. This same approach has been extended to innovative partnerships in learning with mining companies, through the South Australian Chamber of Mines and Energy, schools and the institute, to promote training and careers in mining. The Institute of TAFE Tasmania has adopted a learning culture approach to training packages, whereby more flexible and work-based strategies to facilitate the learning of students are explored. Training packages were an integral part of the overall TAFE Tasmania submission which resulted in their winning the National Training Provider of the Year Award in 2000.

They make innovation a core capability

Innovative organisations prize innovation as a core capability. Leonard-Barton and his associates (1994) describe core capabilities as a 'capacity for action'. Core capabilities are what makes an organisation unique and give it a competitive advantage. To build core capabilities, an organisation needs to adopt an incremental approach to improving and expanding current capabilities. The organisation focuses on process as well as product, and looks for innovative ways to challenge conventional thinking. Innovative enterprises can lose ground, however, when their core capabilities become so embedded in the culture of the organisation that they prevent change. On the other hand, innovative companies establish organisational practices which prevent their developing rigid views about the excellence of their organisation. The Virgin group of companies are well-known innovators: Virgin Management Investment, for instance, continually asks questions which challenge any potential sense of complacency.

In the VET case studies, Gold Coast Institute of TAFE has explicitly built into its strategic planning, an undertaking that it will develop and nurture an innovative culture to encourage research and implementation of innovative products. It plans to build a range of innovation tools and competencies, and will measure the success of these tools by recording the number of innovations on an innovation register. Also looking to the future in terms of using further change to build more innovation capability, TAFE Tasmania is using an explicit benchmarking process to review the relative merits of its achievements on its key performance measures. The senior team at the institute have built benchmarking into their everyday discussions of their achievements, and more significantly, the next strategic goals to be targeted. Like Gold Coast Institute, they also have key performance indicators relating to the learning experiences of students as well as staff.

Innovative organisations identify their innovators

Truly innovative organisations require 'entrepreneurial heroes'—innovators who are out to create wealth and attract resources, be they capital or talent. Although champions come from all levels of the organisation, champions who have more power and responsibility tend be associated with more successful innovations (Amabile, Hadley & Kramer 2003). There is also evidence that multiple champions are a requirement for innovative ventures because of the number of hurdles which must be overcome to be successful.

In earlier work on large industry–VET provider partnerships (Callan & Asworth 2004), we discovered that the success of these partnerships resided with a few champions at different levels of the organisation who were passionate about the financial and non-financial rewards to be gained by working more closely and innovatively with industry. These champions were usually operating with staff who specialised in partnering and who held titles like 'business development manager', 'business manager', 'enterprise officer' and 'partnership manager'. A teacher, with the support of a business manager who was empowered by the leader of the training organisation, typically led this innovative solution to training delivery.

In recent VET case studies (Callan 2004), many examples emerged of how individual teachers are leading the way in developing innovative responses to meet special training situations and learner needs. Through the use of pictorial text and workbooks, puzzles, flexible delivery and special developments in assessment, a teacher at Onkaparinga Institute has modified a number of delivery and assessment strategies to allow individuals with an intellectual disability to complete qualifications in the horticultural field. Another at TAFE Tasmania is driving a project-based learning approach to deliver training to engineering students. The Bleriot XI historic aircraft engineering student project is providing an affordable and achievable project in which the students and staff are involved in researching, designing and assembling a museum-quality flying replica of this aircraft, powered by an original 1909 Anzani aircraft engine. The project was an entry in both the Tasmania Division Engineering Excellence Awards 2003 and the National Engineering Excellence Awards 2003.

People are rewarded for bringing forward innovative ideas

It is people who innovate, not processes or cultures. Successful innovative firms align the organisation's rewards and recognition structures with the goals of innovation. Innovation does not come without cost, and inadequate forms of rewards and recognition are impediments to fostering innovation. Managers play an integral role in enhancing innovation by providing a supportive environment for all employees. It is managers, in particular, who send the signal that innovation is valued, rewarded and important in the organisation. They do this by providing adequate resources, and by attaching the company's means

for reward or recognition to innovation goals. If there is an inadequate reward, employees have little financial or professional incentive to innovate. In addition, those who are innovators become frustrated by the lack of rewards and often move to other places where the financial and non-financial rewards are more explicit (Amabile, Hadley & Kramer 2002).

In technical and further education (TAFE) institutes, there are numerous examples of how innovation is being rewarded through awards and prizes to staff responsible for innovation. These awards can include additional access to training opportunities and visits nationally and internationally to view how other enterprises are promoting learning and innovation. At the same time, compared with the private sector, the public VET system is limited in the financial or other rewards it is able to offer to innovators. In the context of responding more strategically to the issue of rewards for innovation, TAFE Tasmania and Gold Coast Institute of TAFE are implementing recognition programs which publicly support, recognise and celebrate innovative solutions to training.

They use partnerships to bring in new knowledge to drive further innovation

There are two contrasting positions about innovation. One view is that innovation is an internal capability, where outsiders, because of fear of intellectual property loss, are excluded from this knowledge development. The alternative view is that innovation is best seen as a form of 'knowledge brokering' across organisations through partnerships and networks (Hargadon & Sutton 2000). Many people argue that successful innovation requires the latter, including an ability to harvest ideas and expertise from a wide array of sources. The best way to do this is through more formal partnerships, which enable organisations to share their skills and knowledge. Because all partners are interested and involved, partnerships are more likely to mean that innovative projects can be maintained in the event of cutbacks or changed priorities. Partnerships between organisations build levels of trust and produce implicit and explicit arrangements which promote exchanges of resources and knowledge which, in turn, promote innovation in organisations.

Partnerships in VET are being used in numerous ways to promote more innovative programs, consulting opportunities, staff development and change in the workplaces of the providers and industry organisations. The Ford Motor Company of Australia, for example, is using training partnerships to achieve a variety of strategic and change management objectives. The Ford Deakin Prime Alliance provides a range of innovative education programs at the undergraduate and postgraduate levels, supervisory training, research, and consulting services for Ford. This company is also involved in a partnership with Ballarat University (TAFE Division) undertaking a number of Reframing

the Future initiatives funded by the Australian National Training Authority (ANTA). This Reframing the Future initiative promotes opportunities for staff development and organisational change, whereby teams of staff introduce ideas which foster change, collaboration, and team and individual learning in the workplace. Ford is also promoting the careers of students by partnering with various universities to provide scholarships to outstanding female students to encourage women to take up careers in engineering.

Partnerships enable innovations in training delivery; for example, the Barrier Reef Institute of TAFE in partnership with Russco, a body repair shop in Townsville, has re-examined the concept of block release. This institute is able to provide automobile trade apprenticeship training in Far North Queensland without the need to send apprentices to Brisbane for block release. Students are trained through exposure to clients and through workplace projects. Remote locations also create special challenges for delivery that are leading to new innovations. A partnership between Argyle Diamond Mines and Kimberley Group Training, for example, is providing training organised in this remote location, and is tailored to meet the mine's two weeks on, two weeks off, work schedule. The training organisation is providing technical advice, literacy and numeracy assessments, and administration of the training. Different modes of delivery are also being combined in innovative ways by the TAFE NSW Hunter Institute: the institute is delivering courses through its maritime industries partnership by combining teleconferencing, online learning and the use of workplace mentors.

Most partnerships emerging today provide benefits to both parties and involve cooperation, the sharing of resources and the development of 'partnering skills'. Over time, this knowledge and these skills about how to successfully partner become a source of competitive advantage for the enterprises involved. The best of these partnerships are focused upon longer-term outcomes. In an investigation of larger, and typically more commercial VET industry–provider partnerships (Callan & Ashworth 2004), it was discovered that the highest performing VET partnerships thrive on trust, open communication and the sharing of information. They are focused upon achieving a set of goals which both partners agree are challenging and worthwhile. As the training partnership grows and matures, new goals are established.

Partnerships, customisation and innovation go hand in hand. In New South Wales, Western Sydney Institute of TAFE provided tailored training for various industries involved in the Sydney 2000 Olympic Games. This institute, through its partnership with P & O Cold Logistics, is now providing customised training for Woolworths staff who work in cool rooms in temperatures as low as minus 28°C. To achieve its goal of nationally accredited training for call centre employees, the Centrelink partnership with the North Coast Institute of TAFE requires customised and innovative approaches to training and assessment. Possessing the accredited certificate IV, the staff are able to transfer to other call centres with evidence of their knowledge and skills.

The Institute of TAFE Tasmania is involved in a number of innovative partnerships. In a well-known partnership with the catamaran ferry builder, INCAT, it organised the restructuring of the training of INCAT staff, including removing about half of the existing curriculum deemed irrelevant to the company's business needs. The Institute of TAFE Tasmania and the Australian Maritime College are partnering to support the new Australian College in Kuwait. Teaching staff are travelling from Tasmania to Kuwait to complete a number of tasks, including external audits using the Australian Quality Training Framework. The quality process being provided through this partnership is ensuring the continued improvement in customer focus and the development of well-informed students at the Australian College.

The leader's attitude about failure is a key to innovation

Risk is an integral part of innovation. Successful innovative organisations use risk constructively to help the organisation improve and to learn (Denhardt & Denhardt 2002). In a previous NCVER report on the capabilities required to lead and manage in training organisations (Callan 2001), VET managers described nine capabilities. Significantly, one of these capabilities—business and entrepreneurial skills—focused on the ability to promote innovation, creativity, risk-taking and learning among staff. Within this environment, many writers are talking about the 'failure tolerant leader' (for example, Farson & Keyes 2002); that is, someone who stumbles on the innovation path will be forgiven. Failure-tolerant leaders help people overcome fear, and in the process, create a culture of intelligent risk-taking which leads to sustained innovation. They are more likely to engage at a personal level with the people whom they lead. Indeed, research on workplace creativity shows that it is not the individual employee's freedom as much as managerial involvement which produces really creative acts. Numerous case studies reveal that highly competitive companies like Sony, Canon, 3M and Virgin have failure-tolerant leaders who tend to treat mistakes as an opportunity for organisational learning. Managers at 3M, for instance, frequently reinforce the company's mistake-tolerant atmosphere by freely admitting their own mistakes.

Are there failure-tolerant leaders in the VET sector? Almost all of the senior mangers spoken to in the author's most recent case studies (Callan 2004) described how they were attempting to change cultures from being risk-averse to being more risk-tolerant. Staff were being empowered to use training packages to develop more innovative, flexible and customised approaches to the delivery of training. Senior staff were seeing tremendous changes in the willingness of their staff to engage more directly with industry, and to build upon existing partnerships to find additional fee-for-service income. Many of the larger and more commercial industry partnerships in particular had involved decisions which led to the sharing of staff, resources and risks between the provider and the industry partner. Victoria Institute of Technology currently hosts a number of large successful partnerships in transport logistics with

bodies like Connex, MTrains and Linfox, which are being built upon high levels of trust, close working relationships and shared risk-taking. These partnerships are delivering 'clusters of skills' which are immediately useful to various parts of the workforces of their industry partners. In most of the partnerships noted earlier, this same story is being repeated with similar levels of success.

They develop teams and cross-functional teams

Teams are a major tool in promoting both learning and innovation. Recent research shows that such teams must draw upon expertise from across the organisation. The advantages of cross-functional teams are that they allow relationships to be strengthened between functions, while still enabling individual expertise to be active (Leonard-Barton et al. 1994).

Are cross-functional teams being used to promote innovation in VET? Faced with the challenge of bringing together staff from geographically dispersed campuses across Tasmania, the leadership team of TAFE Tasmania has established around 60 delivery teams within learning networks, with team membership ranging across the various campuses. Such teams are identified by the current leadership as critical to the success of the institution in being voted as one of the most innovative training providers in Australia. This institute, in its further efforts to relinquish control and to empower staff, is moving the organisation of delivery teams from institutes to programs, and discussing the further moves to clusters, and in the future, to a single networked organisation.

Highly networked and cohesive teams are also crossing institutional boundaries. The panel-beating teams at the Ithaca campus of Brisbane North Institute of TAFE have established a highly cohesive unit which has proved very willing to be flexible and innovative in how it responds to the different needs of its students. In particular, the flexible and cooperative approach across the two institutions has encouraged more employers to indenture apprentices. Their relationship with employers is supported by regular industry nights. Gold Coast Institute of TAFE has established three cross-functional working groups (user choice, educational and international). Among the roles for these groups is the goal of driving innovation in all facets of educational delivery across the institute.

They create communities of practice which meet regularly to discuss common interests

An extension to the success of project groups is the creation of more informal, collaborative work groups called 'communities of practice' (Wenger & Snyder 2000). In communities of practice, members work together because of shared expertise and a passion for a joint enterprise. They are self-selected team-based structures which can be formed either within a business or across organisations. Such collaborative work groups are usually established in response to an external catalyst or for the purpose of networking with peers

and keeping up to date. People share stories of problems over coffee and the learning from these is applied to the next situation. These conversations turn implicit knowledge into more explicit knowledge which can be shared and possibly used in solving new problems.

In many TAFE institutions, the Reframing the Future initiative has promoted the development of opportunities for staff to discuss and share stories and learning. The Institute of Tasmania used funding provided through this ANTA program to enable staff from three of its campuses to meet and share ideas and strategies. The institute facilitated their meeting with staff from Canberra Institute of Technology and Sunraysia Institute of TAFE to discuss their shared experiences with training packages. TAFE Tasmania is using a workplace assessor group as a form of a community of practice in its horticulture training. Its members meet monthly to discuss issues related to assessment, and to further develop assessor guides and to moderate assessment procedures. The moderation process now includes industry representatives. The institute has also developed a community of practice arrangement with Hewlett-Packard in Melbourne. One outcome of this arrangement was a visit to Tasmania by three senior executives from Hewlett-Packard who workshopped with the senior team of the institute on the topic of the challenges involved in managing organisational change to produce more customer-centric organisations. At the time, these three executives were able to share their insights about the merger taking place between their company and Compaq.

Finally, Gold Coast Institute has developed a community of practice or incubator in which staff in clothing production in the institute are meeting with local industry to investigate new ways of classifying jobs, job roles and new approaches to multiskilling to attract new types of employees who will re-invigorate the clothing manufacture industry in Australia. Industry partners in this incubator arrangement are Billabong, Vodoo Dolls, Salty Tiger and Brothers Nielsen, all of whom specialise in youth and surf wear.

Innovative enterprises provide places to be innovative

'Innovation labs' are another tool being used in a variety of public and private sector organisations worldwide to promote and to teach innovation. The re-invention laboratories created by the United States government within its re-inventing government initiative are one example of such efforts. Experimentation is encouraged through a relaxation of departmental and central agency controls. The laboratories where seed money is allocated involve a two-to-three-day process which aims to assist employees to develop 'rule-busting' ideas. Attendees are encouraged to learn from radical innovations outside their industry, and in groups of eight, they brainstorm ideas for new businesses or new approaches to existing businesses.

Within VET, 'innovation labs' are possibly best exemplified in terms of the growing emergence of skills centres. These innovations are typically high-profile

and have involved substantial government funding, as well as some commercial risk for the partners. In Western Sydney, the Brick Industry Training Company is partnering with Mirvac and Lend Lease Corporation in the construction of 1800 homes over a five-year period. For their on-the-job training, apprentices are working under the supervision of a Mirvac trainer. Off-the-job training, provided by the Technology Park Skills Centre, supports this skills development and learning. In South Australia, manufacturing learning centres are using staff in manufacturing companies as coaches for students who are learning on the job as part of a school-based partnership with Onkaparinga Institute of TAFE and local schools.

In Queensland, the ANTA-funded skills centre provided to Aviation Australia is now participating in training partnerships in aero-skills with a range of clients, including Qantas and Boeing. Also in Queensland, the Construction Training Centre has emerged as a centre of excellence for industry-led, directed and focused training and skills development. The centre acts mostly in a brokering role. Assessment, training and skills development programs at its Salisbury facility are delivered by the centre's training provider partners, all but one of whom lease space at the centre to deliver these programs. In South Australia, manufacturing learning centres involve a partnership between Mitsubishi Motors Australia, the Onkaparinga Institute of TAFE, and various local schools. This partnership is raising the profile of manufacturing and employment in the community by offering school students the chance to undertake on-the-job learning programs.

Shop fronts are being frequently used by VET enterprises to access clients, but also, by virtue of the often commercial nature of the shop front, they provide a working environment in which students and their instructors learn how to meet the needs of customers. These shop fronts include actual or simulated call centres (Tasmania TAFE, Onkaparinga TAFE), beauty salons (Gold Coast TAFE), commercial farming operations (Tasmania TAFE), and a 'shop for the day' concept which has students managing the stock control, pricing, advertising, display and float of the days takings in a small retail outlet on campus (Onkaparinga Institute). In addition, the Institute of TAFE Tasmania uses a shop front in Hobart whereby the tourism industry utilises tourism diploma students for work on real projects. Spencer Institute of TAFE in South Australia is also working with the tourism industry to provide a virtual online tourism office for delivery to remote locations.

In another form of shop front, a mobile tyre training centre is delivering nationally accredited training to youth at risk in South Australia. The mobile training unit is allowing participants in Adelaide, as well as those in remote regions, to complete a certificate II qualification. The partnership is between Youth Education Australia and Bridgestone. This initiative is funded by ANTA, and has received the support of Bridgestone, Cummins, Performance Wheels and Beissbarth Australia in the construction and design of the training unit. Another shop front concept is the Great TAFE Home Work project launched in

2003, in which TAFE students from over 15 course areas are involved in the renovation, electrical engineering, plumbing, interior decorating, furnishing and landscape design of houses and land provided by the Redcliffe Council and Caboolture Council in Queensland. Brisbane Institute of TAFE is coordinating the project. Upon completion of the renovations, a further group of TAFE students from marketing, business and tourism will become involved.

Conclusions

It is clear that many VET organisations across our nation are innovative partners with business. This 'report card', as described earlier, does demonstrate how VET enterprises, particularly through good leadership, clever partnerships with industry, and the use of teams are being innovative.

At the same time, the development of innovation in these training organisations can best be described as uneven, in that certain individuals and teams within institutions are leading the way, rather than a capability for innovation within the organisation itself being the main driver. In the case studies of partnerships (Callan & Ashworth 2004), and in ongoing work on innovative VET organisations (Callan 2004), no single institution has emerged as one where innovation is a core capability—a major test of being an innovative enterprise. Nor did any chief executive officer of a VET organisation claim that they were in charge of an innovative organisation, but rather that they had begun the journey, with some exceptional individuals leading the way in developing more responsive and flexible training solutions for industry.

However, putting this into context, in Australia today very few of our businesses are being profiled in the media or in our day-to-day conversations as innovators. The growth in 'Smart State' initiatives by at least three states, as well as the federal government's strategies are heralding a somewhat late Australian entry into the promotion of innovation as an industry and national priority (that is, Innovation Action Plan for the Future, and the Backing Australia's Ability program, providing $2.9 billion over five years). Importantly, the case studies profiled in this chapter encourage optimism about the VET sector's potential in the longer term to contribute to this national endeavour to build more innovative Australian enterprises.

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Vocational education and training engaging with emerging industries

Opportunity analysis model

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Previous studies have had little success in defining emerging industries and have instead, defined emerging technologies. To enable the vocational education and training (VET) system to contribute to the development of skills within emerging industries, it needs to be able to identify potential business partners. In this chapter the authors outline a mechanism, the 'opportunity analysis model', which assists enterprises in identifying emerging industries. Emerging industries do not always use new technologies but can emerge as a result of changes in government policy, changes in priorities in a community, and from changes in technology and innovation. The opportunity analysis model is provided to assist VET providers in identifying those emerging industries likely to proceed. In order to recognise training opportunities within emerging industries, as well as create them, it is suggested that VET providers assign a specific person with the task of researching the commercial environment, with a focus on establishing networks with industry and research departments of commercial and academic institutions. However, it is important to realise that barriers, such as the current structure of training packages, which are more suited to established industries and technologies, may prove difficult when implementing innovative training programs.

Introduction

IT HAS RECENTLY been suggested, in relation to the VET sector, that there should be an increased focus on identifying the trends of emerging industries, changes in technology and the anticipation of training needs of innovative or emerging industries (Whittingham 2003). The early recognition of changes in required skill sets and associated training can provide a nation or industry with

increases in productivity and competitive ability (Long & Fischer 2002). Vocational education and training has, therefore, an important role to play in providing structured training to emerging and innovative industries.

To enable a VET provider to correctly assess the risk involved in engaging with emerging industries, this chapter proposes the 'opportunity analysis model' for this purpose. The chapter also suggests some areas in which a VET provider could develop opportunities for engaging with emerging industries.

Emerging industries and new skills

As noted in the chapter by Misko and Saunders, previous studies have had little success in defining emerging industries and have tended to define emerging technologies instead (Department of Education, Science and Training 2002; Misko & Saunders 2004; Lindhjem 2003). Emerging industries are found where there is an expanding knowledge base, where existing markets are experiencing innovation, or where new markets are being developed (Day & Schoemaker 2000). New industries sometimes emerge as a result of scientific discoveries which result in previously undiscovered processes and products. Examples of these types of industries are biotechnology, genetic modification and nanotechnology. Other industries can be said to be emerging although they do not utilise new scientific processes. Examples of these are knowledge management, environmental conservation, aged care and home entertainment networks.

When we think of emerging industries, we are usually thinking about the emerging technologies affecting existing industries. In these circumstances the implicit assumption is that the technology is new and very advanced. Sometimes it is the use of mature technologies in new ways which provides existing industries with the tools to enter into new markets, or perhaps it occurs through the revision of the patterns of consumption within existing markets.

Even when a new technology is introduced, those working with it are required to utilise not only the specific aspects of the new technology, but also ancillary, non-technical and generic skills. These non-technical skills become equally important in an emerging industry and there is growing interest in defining these skills (see Kearns 2001). The use of new technology requires more attention rather than less, and while it seems to eliminate some problems, others will inevitably arise. Therefore the person using the emerging technology will need to be attentive to these subtle changes (Tenner 1996); generic skill sets will become more important as the complexity of technology increases.

Three factors may be perceived to limit the VET system's participation with emerging industries. One is that VET providers have structures based around models of mass market education. Another is that VET providers are constrained in their ability to respond to market demands due to traditional delivery models and time required to develop new courses. Finally, VET providers sometimes experience difficulty in delivering specialised skills across

a broad range of subjects. It is important that VET providers who are considering engaging with emerging industries be aware of these perceived limitations.

Opportunity analysis model

Background to the model

One of the prime challenges for the VET sector is being able to recognise emerging industries and assess the status of those industries in order to identify the point at which they warrant the development or modification of training. The task of identifying emerging industries has traditionally been difficult due to a number of factors. Firstly, the landscape for emerging markets is very broad, requiring a field of view challenging for most observers. The scoping process either results in very generic findings based upon general market research or very specific results based upon qualitative data and the views of a number of key stakeholders. Within the information technology industry, there are estimated to be approximately 4188 unique 'active' skills (IT Skills Hub 2003). These skill sets are changing continually and this highlights the enormity of the task.

Secondly, there is a lack of tools and frameworks for assessing trends, and this makes it difficult for decisions to be made based upon sound reasoning and quantifiable judgement. Usually a VET provider would use employment statistics, surveys or economic data to try to anticipate the market. Although information on past growth is useful, these tools provide little help in predicting the future.

Thirdly, the current methods used for predicting and assessing trends tend to consider single sources of data rather than providing a framework for the balanced consideration of all relevant factors. For example, while employment statistics are a good indicator of current skill requirements, they do little to anticipate future market opportunities and would rarely help to identify emerging industries.

Finally, the pace of change is extremely rapid. While organisations may still use a 5-year strategic plan, these plans should not be static and they require continual review to allow an organisation to respond to market developments. To enable a strategic response to these challenges, it is suggested that a more structured model is required, one which has the capacity to balance the particular factors important to the assessment of emerging industries.

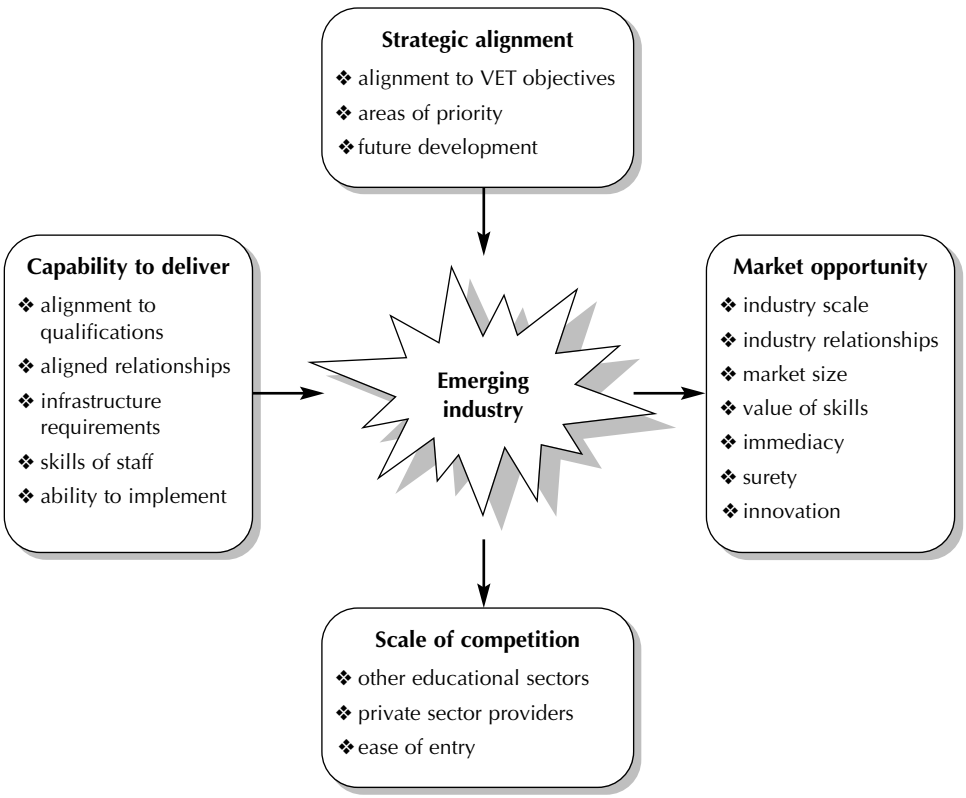
Summary of the model

The 'opportunity analysis model' (figure 1) has been developed by one of the authors (Royle) and has been used as part of a research project for Central TAFE in Western Australia. This model was proposed as a method for considering the

detailed assessment of technology trends but is equally applicable at a higher level to assess emerging industries.

The model is based upon an adaptation of a blend of formal approaches to disciplines. These include risk management, as well as modern strategic management models, including the 'balanced scorecard' which considers not only the financial aspects of an organisation, but also the customer, learning and development within the organisation and internal processes—in other words, an organisational framework supporting all aspects of the organisation. The basis for the model has been the creation of a framework which allows for the consideration of all relevant factors in the assessment of emerging industries.

Figure 1: Opportunity analysis model



The four main dimensions against which emerging industries should be assessed are elaborated below.

Strategic alignment

The emerging industry is assessed according to its strategic alignment to the objectives of VET providers. These objectives may determine the relevance of an emerging industry to VET priorities. For example, at a local level, certain

industries are likely to be of greater importance and thus the resulting skill needs are likely to be specific to that particular region.

Market opportunity

The market opportunity assesses the potential commercial scale of the training need. Many emerging industries are likely to have a limited requirement for niche skills. Other industries will have the potential to be more widespread and the demand for skills will be much higher.

Scale of competition

The scale of competition considers the ability and positioning of other training providers to meet the demand for skills. Consideration is given to the existing credibility and capabilities of other training providers and their relevance to the emerging industry. Given that training organisations often establish market credibility within particular areas, there may be a risk that other local providers are better placed to leverage their existing market position to service the new market. Furthermore, the delivery of training may require specialised infrastructure and equipment to support training which may already be available through other training providers. This may inhibit the ability of the VET provider to compete and to capitalise upon market opportunities.

Capability to deliver

The capability to deliver considers the parameters associated with the ability for VET providers to respond to the needs of an emerging market. It considers aspects related to the development of appropriate training programs, such as the skills of staff, the requirements for infrastructure, as well as the nature of the existing industry relationships which VET providers can use to develop effective training materials.

Opportunity assessment

Each of these four dimensions can be reduced to a number of detailed criteria through which a potential opportunity can be assessed. These assessment criteria are a combination of both qualitative and quantitative factors. Examples of quantitative criteria include:

- the number of employment advertisements within a particular sector or which identify particular skills
- financial analysis and market forecasts
- VET college staff skills databases
- analysis of industry relationships
- details of particular commercial agreements and projects.

Additional qualitative criteria can also be used as part of the analysis. These criteria rely on comparative insights gained through a number of mechanisms, such as industry surveys, interviews or other issues arising from industry associations. These insights may support the identification of emerging trends, as well as providing value within the assessment process.

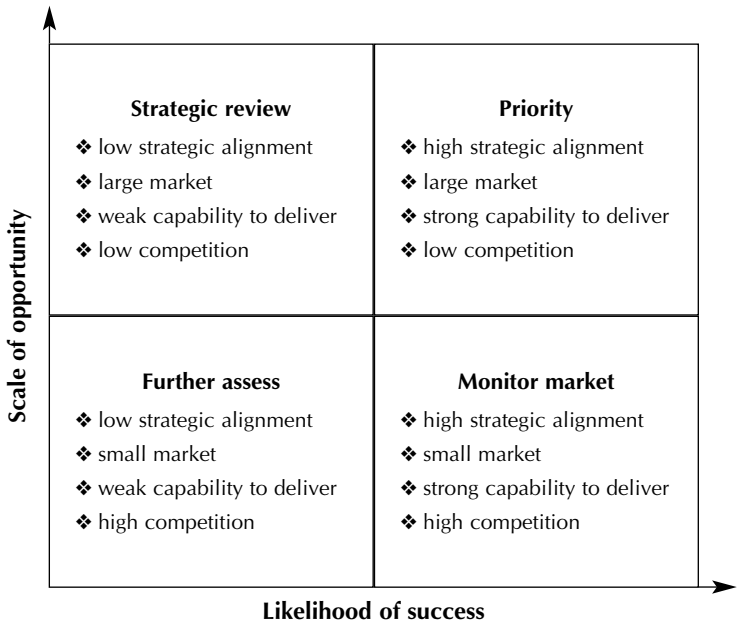
Interpreting the results

The results from the analysis can be conflated to produce a two-dimensional mechanism for comparing opportunities. The dimensions are:

- *scale of opportunity*: market opportunity *minus* the scale of the competition
- *likelihood of success*: strategic alignment *plus* the capability to deliver.

These two scores can then be plotted into an opportunity analysis graph (figure 2) to show a comparative assessment of the results.

Figure 2: Opportunity analysis graph



The relative position of opportunities on the graph provides certain insights which are explained below:

- *Priority*: opportunities in this area should be given priority as they represent a high likelihood of success.
- *Strategic review*: opportunities in this area should feed into any review of VET strategic capabilities.

- *Monitor market*: activities in this area have a smaller scale of opportunity and therefore are likely to be of lower priority, but nevertheless warrant monitoring.
- *Further assess*: activities in this area are likely to be of lowest priority as they represent low-scale opportunities and a low likelihood of success.

Using the model

It is important that the model is applied regularly in order to identify new opportunities, as well as to assess the repositioning of previously identified industries. The development of appropriate assessment criteria and the provision of appropriate 'sensors' ensure that the model is relatively straightforward to use. In addition, it is worth emphasising that the model should be considered as a tool for the analysis of opportunities and in support of the decision-making process. It should not be relied upon as a definitive guide to drive business decisions.

The role of vocational education and training in emerging industries

As VET delivery encompasses a range of organisations which are publicly funded or privately owned, the degree of flexibility across this sector ranges from small to large. Smaller, privately owned training providers are perhaps the most nimble of all, in that changes in the content of training can be made quickly and without bureaucratic intervention or cultural change. It is for this reason that many observers of innovative organisations suggest that a new and smaller enterprise be established where new ideas can be easily adopted (Bower & Christensen 1994).

However, opportunities do exist for large, publicly funded training providers. As emerging industries utilise a range of existing skill sets and sometimes new science and technology, it may be helpful to think of these industries as using a 'skills portfolio' approach (Fenn, Linden & Fairchok 2003; Miller & Morris 1999), whereby some training is offered in new areas but other training utilises traditional training. This approach gives larger training providers an opportunity to cover all technology and skill areas in a way in which smaller training providers cannot. However, this approach also requires these larger organisations to work across disciplines within the institution.

In addition, a portfolio approach would assist in meeting training requirements in emerging industries. An employer would choose the training required from the traditional skill areas, as well as submit 'special orders' to meet specific needs. Obviously, the more flexible the training provider is to the needs of the client, the greater are the opportunities for customer satisfaction. The training provider does not necessarily need to 'manufacture' the special

order, but can call upon a range of suppliers for these non-standard and specific-use training requirements.

It may be appropriate here to briefly address the position of vocational education and training in the total training market. While many organisations would like to be at the 'leading edge' or 'bleeding edge' of technological innovation, it may not be necessary for the VET sector to position itself at this level in order to be relevant to emerging industries. It is acknowledged that the VET sector is considered by some managers of emerging industries as being providers of more traditional training and having little relevance to 'high tech' industries (Ferrier, Trood & Whittingham 2003). While this seems to limit opportunities, the VET sector can happily sit on the 'blunt edge' of training and can act as a broker for this higher technology and science-knowledge training.

As mentioned earlier, not all emerging industries will be using new high-tech processes—some emerging industries may use existing processes in new ways. The VET sector, by assembling currently disparate and mature skills in new combinations, may be in the position to provide appropriate training to these emerging industries.

Recognising opportunities

The aim of this chapter is to offer VET providers suggestions on how they might identify and engage with emerging industries. The following sections highlight some of the areas and associated processes which should become part of normal practice. Some of the suggestions given here are relevant to all staff members, while others highlight those most appropriate for specific roles. In the context of provision of training to emerging industries, it is important to remember that emerging industries often have tacit and implicit knowledge associated with the technology and processes, and are generally workplace-based. The VET provider therefore needs to be able to identify both the specific technology requirements as well as cultural aspects of the industry and the workplace.

There have been some suggestions that national bodies should provide some assistance in the identification of these industries and skills (Ferrier, Trood & Whittingham 2003; Whittingham 2003) and this recommendation is supported in this chapter. However, it is important that the VET provider does not wait for instruction from these groups and should proactively make decisions based upon local requirements (Chappell et al. 2003).

Environment scanning

There is a need for a specific individual within an enterprise to be attuned to the commercial environment in order to recognise opportunities for training. This role may be contained within performance criteria for program managers or other staff members. However, this role is sometimes more appropriate to non-

affiliated researchers who would not be limited in their selection of possible opportunities. It is assumed that someone in this position would be objective and would not be asked to consider the difficulties in the implementation of the idea, but to offer a range of suggestions. In a sense this is a 'pure' research activity.

A number of organisations are incorporating the activity of environment scanning into the strategic planning process since this provides the organisation with a formal mechanism for recognising opportunities. This is not a new concept but the processes used need to ensure that subjective assessments do not limit the data or opportunities. In this planning process an organisation should question the assumptions it holds about itself in order to be more externally focused to recognise opportunities (Johnson & Hawke 2002).

In order to achieve this, it is suggested that the VET sector undertake a blend of reactive and proactive activities to monitor the environment. Some suggested sources of information are:

- *Industry and science journals*: these may be industry or technology-focused and should support the VET sector in identifying, assessing, and tracking the development of emerging industries.
- *Research departments*: one of the primary sources of emerging industries are the research departments of commercial or academic institutions and it is important that the VET sector maintains relationships with such organisations.
- *Government publications*: government agencies issue publications which identify emerging industries and include statistics from the Australian Bureau of Statistics, the National Office of the Information Economy, the Department of Employment and Workplace Relations, and the Department of Education, Science and Training.
- *Recruitment trends*: recruitment trends are a useful mechanism for monitoring the growth of new industries based upon the demand from the marketplace for related skills.

The sources of information may be considered to be reactive; however, there are also a number of more proactive methods the VET sector can adopt to identify emerging industries. An emphasis on maintaining close industry relationships is one important proactive mechanism. The VET sector can utilise these industry relationships to identify emerging industries and their associated commercial developments.

Another way is to emphasise fee-for-service courses. This provides a useful way to test the market demand for skill sets associated with emerging industries and forms a relatively low-risk approach when engaging with emerging industries. Given that the VET sector can be relatively flexible in developing and delivering these courses, this can be a useful means for testing and monitoring the market.

Gathering and sharing ideas

The creation of cross-disciplinary networks has the potential to increase the number of links between an organisation and emerging issues. The ability to network is critical to the early identification of opportunities. Networks are generally established in two ways—by employees attending national or international conferences, which is expensive, or by having employees provide voluntary 'lunch time' seminars on important or interesting work that they are planning or undertaking. While this activity is internal to the organisation, it provides a process through which the exchange of ideas across disciplines can occur. The latter process is less expensive.

An example—assessing an emerging industry

As an example of an emerging industry, knowledge management provides a useful case study. While many of the behaviours associated with knowledge management have always been an inherent part of business activities, it is only relatively recently that commercial priorities have focused upon knowledge management as a means of adding value. This has resulted in knowledge management becoming recognised as an 'industry' in its own right, with formalised applications, processes and organisations being created to service this industry.

As with many emerging industries, it cannot be claimed that knowledge management as an identifiable industry was developed at a specific point in time, but rather it has evolved over a long period. During its evolution a number of factors have facilitated its development into an emerging industry:

- *Market developments*: the need for improved efficiency, reduced risks, product innovation, and closer customer relationships has created a driver for improved knowledge-sharing between organisations.
- *Technological and scientific development*: technology has improved the ability of organisations to implement more effective knowledge management solutions through its information-sharing capability over disparate locations, as well as supporting new forms of both synchronous and asynchronous communications.
- *Innovation*: to some degree, innovation in the more detailed applications and the processes to help organisations succeed in knowledge management should be considered as an enabler.

The point at which knowledge management could be considered a priority for the VET sector will depend on a number of local factors. However, the initial identification of the industry as offering potential for VET provision could be expected to arise if the mechanisms outlined above (journals, research departments, government publications etc.) are utilised. The recent publication

by Standards Australia of a knowledge management standard has added a degree of credibility and maturity to the discipline in the marketplace, as well as providing a recognised definition and structure.

The levels of demand from local industry would also be crucial to any implementation decision. As outlined earlier, the opportunity analysis model provides a useful tool to compare this trend with others and assists in balancing strategic and market factors when making assessments.

Knowledge management may be defined as an emerging industry, since the processes used in the collection of data in the modern workplace are still being developed, innovation of processes is taking place and this activity is creating new markets. Knowledge management is not dependent upon any particular technology and is based upon the generation of value from the knowledge held by individuals, departments and cooperating organisations.

At present there are only a handful of good examples and only a few organisations are able to claim expertise in this area. As a result, there are no clearly defined rules or processes. Such is the nature of emerging industries. Using the opportunity analysis model (figure 1) this industry can be analysed to identify a role for the VET sector.

Strategic alignment

One of the major objectives of the VET sector is to provide industry with the training required to meet that industry's needs. Many organisations are still working through the issues involved in knowledge management and in this regard, a large VET provider would be no different. It is likely that large VET providers are already working on developing their own knowledge management processes in order to reduce costs, increase efficiency and meet regulatory requirements, such as preparing for audits by the Australian Quality Training Framework. By placing a priority on knowledge management and developing the expertise in-house, a VET provider may be ideally positioned to offer assistance to industry.

Capability to deliver

The Information Technology Training Package contains a number of qualifications which relate directly to the processes of knowledge management, such as web design, website administration, database management, and including a diploma in knowledge management. These qualifications and other technically focused and human resource-related qualifications would also be required to support a knowledge management system. VET providers would need to develop relationships with other enterprises to 'fill the gaps' in order to develop a more complete infrastructure.

As with all emerging industries, there would be a need for recruitment of new staff. Moreover, existing staff would require professional development. It is important to emphasise that, if the VET provider can demonstrate competence in knowledge management, they stand to gain both through consultancy services and through direct training to organisations planning knowledge management systems.

Likelihood of success

The combination of the 'strategic alignment' and 'capability to deliver' form the 'likelihood of success' in the opportunity analysis graph (figure 2). After reviewing its abilities, strategic focus and priorities, a VET provider may choose to enter into the knowledge management industry as a consultant and trainer. Success will depend upon the presence of factors such as skill sets, funding, top-level management support, the structure of the organisation and collaborative arrangements, as well as the timing of entry.

If a VET provider is not strong in the areas of information technology, human resources and other related areas, nor is willing to invest in these areas, then it will be low on the 'likelihood of success' axis. In this case the VET provider would consider knowledge management in the two left quadrants in the graph (figure 2) being 'strategic review' and 'further assess'. If a VET provider has strong capacity in its alignment and ability to provide this training, then it may see this industry in the two right quadrants in the graph—'priority' and 'monitor market'.

Market opportunity

The scope for knowledge management is likely to grow and create a large-scale opportunity for enterprises to become involved. As this area is an emerging industry, no single provider of products or services will be able to meet all of the needs of this industry. Therefore appropriate relationships will need to be developed. A large VET provider should be able to manage the development of collaborative arrangements, using a range of people/organisations with appropriate skills in management, education, change management, web services and other specialisations. Innovation will be critical in this process.

Scale of competition

There are a few individuals and enterprises who are currently promoting themselves as knowledge management consultants. A VET provider who is able to demonstrate a working knowledge and a working system will be able to provide tangible solutions to other large organisations. Therefore a VET provider would be able to demonstrate superior skills to the market once these systems are in use and working effectively. This could then position a VET provider as the preferred supplier for consultancy and training.

Scale of opportunity

The 'market opportunity' less the 'scale of competition' provides for the 'scale of opportunity' on the opportunity analysis graph. The growth in the market will be high, but there will also be many individuals participating in this emerging industry. A VET provider would need to decide whether to support another organisation (such as in training the enterprise's staff) or to enter directly into this market as a consultant and trainer.

A VET provider who has developed expertise in knowledge management will be able to provide superior service and will see this industry in the top two quadrants of the graph (figure 2). Those providers who believe that others will be able to address this market more efficiently will see knowledge management in the bottom two quadrants in the graph.

Summary of example

This example, which uses the emerging industry of knowledge management, demonstrates how the opportunity analysis model can be applied to emerging industries. Although this is one tool that may be used when approaching strategic decision-making, it does allow for the inclusion of a number of variables. The variables included in the opportunity analysis may be changed to suit the particular requirements of the VET provider.

Creating opportunities

Opportunities are identified through a process of innovation. Innovation is sometimes achieved through the combination of two technologies or processes which initially appear unrelated. In order to recognise these opportunities, it is necessary to develop networks to provide for data collection and this requires an engagement with customers, employees and even competitors. The following suggestions may enable a VET provider to increase its knowledge of these possibilities and to act upon them through engagement with these important groups.

Consulting

Chappell et al. (2003) suggest that 'formal education and training is no longer a stand-alone intervention in economic productivity—to have full effect, it must be more systematically linked to wider strategic human resource management strategies' (p.10) and that the training provider now has the opportunity to act 'as a consultant and advisor on organisational change' (p.31).

This can be accomplished by engaging with industry to gain the support of prospective clients. As the Office of Training and Tertiary Education notes, in order to 'win the confidence of the corporate sector, tenured staff must engage

with the issues of change, both theoretically as analysts and researchers, and practically as academic workers involved in increasingly knowledge-driven enterprises' (2003, p.9)

The VET provider would be able to act as a contractor for learning and development services within emerging enterprises, or participate as a partner with these new ventures. In the context of development activities, it is possible that these activities could be undertaken by an employee within the emerging organisation through the auspices of the VET provider. However, initiatives such as this may require some redefinition of the roles and goals of the traditional VET provider.

Skill requirement definition

Prior to the introduction of training packages, defining job characteristics was a lengthy and expensive process. Fortunately for Australian enterprises, training packages enable managers to more quickly define the skill requirements or core dimensions of emerging employment positions.

Through discussions with knowledgeable enterprise staff, a VET provider would be able to analyse the performance expectations of an employment task and reduce these to units of competency. The training program outlined could be used to plan and deliver training to meet operational targets as well as for assessment. In this way the VET provider has the capacity to act as a strategic partner in workforce planning and subsequent training, which is critical for emerging and growing enterprises.

Mentoring

The modern workplace has a flat management structure where frontline operatives are required to have more management skills than previously (Dumbrell, de Montfort & Finnegan 2002) and supervisors are no longer charged with solving technical problems but have to ensure that outcomes are achieved using delegation and project management skills (Herber, Singh & Useem 2000). Frontline operatives should have the technical and generic skills to accomplish the task through training and years of experience. However, some individuals may be promoted to these positions and may have not had sufficient management or supervisory experience.

Due to the highly contextualised nature of the workplace, it may be difficult to provide classroom-based training or e-learning opportunities which will address adequately the concerns of a newly appointed employee. The use of a mentoring arrangement may be one way of assisting the novice supervisor in this environment. As VET providers do work within and across many technology-related areas, the institution may have developed contacts who can be called upon to provide this mentoring. Many retired or semi-retired persons are able and willing to participate in such activities and should be identified for such opportunities.

Development of networks

Although employees in an emerging enterprise may already possess the requisite skills and knowledge to undertake their work, the provision of appropriate networks to facilitate cross-fertilisation of ideas is crucial. Thus the capacity of an emerging enterprise to develop these networks is an important issue. Similarly, if a VET provider is to work successfully with an emerging industry, it will need to develop workable networks within the training sector to meet the needs of its clients. On occasions this may mean working with other public or private training providers who may appear to be competitors.

A term has been developed to cover this type of partnership—'co-optition'—and is a combination of the words 'cooperation' and 'competition' and signifies the productive working relationship an organisation can have when working with competing organisations. Many tenders for a range of equipment and services in information technology are often developed by organisations working together who are competitors, but by working together can add significant value to the contract.

In emerging industries, the market for training is limited and the long-term viability of the industry will not have yet been demonstrated. There is risk associated with entering this market and this risk may be reduced by utilising the core strengths of other training providers. For example, the VET provider could adopt the position of a consultant for this training, using its core strengths in traditional skills training and the management of training, while skilled contractors could be used in the delivery of specialised training. This then becomes a process which adds value to the training and reduces risk.

In this scenario the VET provider can utilise training provided by vendors, technology specialists and even universities, in meeting the client's requirements. This training would then be highly relevant for the employer who is focused on outcomes for the enterprise and not concerned with training that necessarily results in nationally recognised qualifications (Chappell et al. 2003).

Implementing and capitalising upon opportunities

As identified earlier, emerging industries are risky ventures and not all succeed. We have identified some parameters leading to the success of an emerging industry. VET providers should be cautious when engaging with high-risk ventures and should be cautious about their partnership arrangements; that is, VET providers should pick and choose their opportunities. Ferrier, Trood and Whittingham (2003) recognise that responses to new skill requirements can present some difficulty for the public VET system. These include:

- Not all new skill requirements become formal training needs.
- High-risk investments in equipment by public VET system providers may not be in the public interest.

- ❖ The stage at which the provider enters the market is important.
- ❖ The need for industry-specific knowledge for contextualisation should be considered.

Cross-disciplinary issues

As emerging industries use old and new technology and processes in different ways, the VET provider needs to ensure that the full capability of the organisation is utilised in providing training in these areas. Government bureaucracies are often criticised for being too insular and adopting a narrow perspective in relation to what each should do. On many occasions this insular approach does not lead to a sharing of information but confines information into 'silos' and limits the construction of informal and formal networks.

The large VET provider should consider a matrix-style organisational structure for the delivery of training in emerging industries. In future, when enterprise-focused training is undertaken, the departments charged with the responsibility for managing that training may tend to use intra-departmental staff, a situation more likely the result of budget constraints rather than the deliberate selection of more appropriately skilled individuals from other departments.

This matrix-style of organisation is used commonly in research and development and should become standard practice in all organisations dealing with emerging industries. This style of working also requires new processes and changes in attitudes within the traditional larger VET provider.

Barriers for VET in emerging industries

While a large part of the preceding has focused upon the opportunities available to the VET sector, it must be remembered that, in some areas of training delivery, especially in public VET institutions, there remain some difficulties in implementing innovative programs in newly defined technology with their specific skill requirements.

Training packages

Training in public VET institutions in Australia utilises training packages for the delivery of training and assessment. These packages are developed by industry advisory bodies through a consultation process with industry representatives who are usually from larger enterprises. For mature industries and technologies, this process works reasonably well, but within emerging industries, difficulties are often encountered. Firstly, there is the need for highly flexible combinations of relevant units of competency within qualifications which would allow for suitably contextualised training. While there is the ability to 'import' units of

competency from other training packages, there is sometimes little commonality at high levels of complexity across the packages (Leary 2003).

Secondly, new technologies sometimes require new skills, and the process of creating and endorsing new units of competency can be a lengthy one. Thus using these training packages becomes more cumbersome than if training were to be delivered based only upon the needs of the enterprise in a fee-for-service arrangement and without national recognition of the training. This difficulty has been highlighted by TAFE Directors Australia (2003), with concerns expressed that the development, review and additions to training packages needs further consideration.

Knowledge inversion

Access to the internet has increased the opportunities for the dissemination of knowledge through search engines which provide fast, cheap and highly efficient data searches. As a result, some lecturers are made aware of new technologies and processes through interaction with their students. This situation has been described as 'knowledge inversion' where the student knows more about some topics than the lecturer. While this may have been embarrassing for a lecturer ten years ago, it should not be the case now.

As access to quality information is widely available and as new developments are occurring continuously, it is unrealistic to expect that one person would be aware of all new developments. VET providers need to be aware of this issue and accept the situation as being part of the process. Knowledge inversion should not be viewed as a deficiency in levels of competence of a lecturer or other staff, but as an opportunity to investigate new and emerging areas.

This concept of knowledge inversion is also one facing management in many technology-oriented enterprises. That is, the frontline employees are sometimes more aware of emerging technology and processes and present management with ideas and opportunities for which they are not prepared. There will be an increasing need for managers to have the skills required to manage ambiguity and make decisions without a full knowledge of a technology.

Conclusion

This chapter highlights the need for each enterprise, institution and organisation to undertake its own analysis of the opportunities available within emerging industries. The opportunity analysis model provides strategists with a tool which facilitates this analysis and includes a broader perspective.

VET providers are able to contribute in a meaningful way to the skill development within emerging industries. While some emerging industries will

use 'high tech' processes, the VET provider has the capacity to provide the supporting skill training as well as the management processes for training throughout the enterprise.

In achieving this, the traditional VET provider will need to become more involved in personalising the skill training requirements for enterprises and act as a consultant in this process. This will also require the traditional VET provider to develop new organisational structures which work across disciplines in an effective way. Furthermore, it is important to recognise that the delivery of this training may not be conducted in a traditional way, but may call upon external providers and mentors.

Within emerging industries, opportunities exist for the VET sector to provide skill and knowledge development, but there are also challenges to be met. For mature industries, the traditional VET structure is likely to meet the needs of industry. However, for emerging industries or industries experiencing rapid change, the traditional VET structure will need to undergo radical restructure to meet these new challenges and develop new network arrangements, both within the organisation and with others.

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Tackling emergent needs

The Applied Technology Framework project

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This chapter describes the development and implementation of the Applied Technology Framework. This is a curriculum initiative designed to meet the needs of post-trade (or equivalent) workers in those industry areas where there is no existing culture of lifelong learning and where technological change is occurring at a faster-than-average pace.

In order to recognise the realities of learning through work and from others within a community of practice, the concept is based on an accredited training framework rather than on accredited qualifications. Underpinning this is the assumption that learning is not uniform or developmental; rather, that learning is shaped by the context and the learner's interaction with this context. In addition, the outcomes of the learning are not necessarily known at the outset of the learning experience, as learning in such circumstances is expansive and unbounded.

The framework is still at an experimental stage and is being piloted within the precision manufacturing, plumbing and waste management industries. One pilot program has been completed and others have begun. The response of industry has been very positive, with enterprises volunteering to be part of the project and to pay for the experience—to the extent that there is an urgent need for professional development of teaching staff to enable the current demand to be met.

Introduction

THE INTRODUCTION OF training packages in Australia, as the specification of training outcomes, has provided registered training organisations with a greater degree of flexibility in meeting industry enterprise training needs than was available under the previous system/s. Nationally endorsed training packages provide a specification framework which covers: the endorsed competency standards for that industry sector; the rules for the award of recognised credentials; and the standards governing the assessment processes

leading to the gaining of qualifications. However, in a world characterised by rapid and continual technological change and the consequential merging of traditional industry and/or discipline streams, the flexibility currently enabled by training packages is sometimes not sufficient to meet enterprise needs.

By the time a training package has been endorsed, it has undergone an extensive period of consultation and development. While this might be said to have assured its validity, this process has not necessarily ensured its timeliness or its comprehensiveness. It is, like all such moderated documentation, a prescription based on past and present needs and does not cater for emerging or future needs. Within industry areas where the rate of change is comparatively slow, this is not problematic, given the facility for customisation. It is only in those areas where changes in work practice are rapid and ongoing or in newly emerging industry areas that this causes significant problems.

Planning and training for emerging and future needs is a difficult and risky task. Not only is it difficult to imagine the specific skills which might be needed, but it is almost impossible to train people for tasks which do not yet exist—using technology which has not yet been designed. Learning for the future must be grounded in preparation for future work and future developments.

The first stage of the Applied Technology Framework project has been undertaken this year by a team of RMIT University staff with the assistance of funding from the Victorian Office of Training and Tertiary Education. It is designed to promote new product development and aims to prepare post-trade and equivalent workers, who are already working in industry, for their future learning as well as to provide them with the additional skills and knowledge required now.

Aims of the project

The major objective of this initiative is to develop a recognition and curriculum framework which will facilitate the development and delivery of applied technology programs which:

- relate to one another and thus provide development frameworks which link to job and career structures within a number of industry sectors
- enable the lifelong development of design, process, project management and business competence as well as acquisition of current and emerging technical competencies
- allow for cross-sectoral skill development
- can be easily broken up into relatively short intensive programs to meet the needs of individuals and specific industry enterprises
- use mentoring, active learning approaches and reflective practice to integrate formal and experiential learning within the context of the workplace

- provide multiple entry and exit points which enable them to be accessed in a variety of ways.

Workplace learning

Learning while working is increasingly essential if we are to keep pace with technological and organisational change and to contribute to the intellectual and social capital of our workplaces. While it might be argued that not all work results in learning—routine repetitive tasks once mastered are unlikely to result in new learning—much of it does (Barnett 1999, 2002). A lot of this new learning takes place in response to new or contingent situations where the learner must adapt what he or she knows to resolve an issue, solve a problem or learn to adapt in response to new organisational structures, functions, work systems or technology.

Workplace learning is a purposeful, dynamic activity in which workers interact with the work context—its people, culture, organisational history, work systems, processes, procedures, physical nature and emotional ambience—in order to better understand and work within it. As workers achieve this, they construct and reconstruct working identities and understandings. Workplace learning requires effort, and workplaces are by no means benign environments.

Much workplace learning is situated learning—taking place in specific contexts—and it is the 'situatedness' (Lave & Wenger 1991) of this learning and the learner which determines what is learnt and how it is learnt. New skills and knowledge are not learnt through memorising or internalising; instead, they are enacted by the learner as part of work practice.

Essential to workplace performance and learning through work are the affordances (or opportunities) to learn, which the workplace offers and the extent to which learners are able to influence this. As Billet notes:

> *… how affordances are constituted in workplaces, are shaped by workplace hierarchies, group affiliations, personal relations, workplace cliques and cultural practices, as well as the kinds of activities in which individuals are able or requested to engage.* (Billet 2000, p.31)

Kim Kirsner (2002, p.18) notes that studies of surgeons in Canada found that surgical skill was positively correlated with practice in carrying out a particular operation; that is, that the more experience a surgeon had, the better s/he became at that operation. The surprising finding was that, as their performance improved, their ability to pass the examinations which gave them entry into their profession actually declined until, decades later, they were struggling to answer many basic questions.

A number of studies with fire-fighters, nurses and others have confirmed such findings. Because we learn from our work experience by enacting our learning within our practice, it is implicit (or tacit) knowledge and becomes,

over time, unconsciously embedded in our practice. We mimic the practice of our mentors and models without necessarily giving conscious thought as to why we are doing it.

While such tacit knowledge enhances our performance, it remains unspoken and, therefore, cannot be shared with others. It is only by reflecting on our work practice that we can examine the component parts and transform such implicit knowledge into explicit knowledge. This is important if we are to work collaboratively or to teach or train others. This was acknowledged by respondents of a situated learning research project (Down forthcoming) when one of them wrote:

> *It is only through reflection of what we do, that we can identify how our practice is changing, what is new and what we no longer do. By rationalising these changes, we add to our theoretical understandings of learning and our work.*
> (Research participant, cited in Down [forthcoming])

Thus, effective learning occurs through work and through the systematic reflection on that experience. Learning can also occur from others—either by listening to what they have to say, watching how they work or reading what they have written. However, learning is more likely to take place when active questioning and reflection occurs. It is the seeking-out of information and reflection on this which enables the learner to gain knowledge and make it their own by using it in their practice.

Bounded learning

Most of the learning we do is bounded learning; that is, the knowledge we are seeking is already known, there is an expert to guide us, and we know the outcome we are seeking.

Unbounded learning

When we are doing something new, such as exploring, implementing and using technology which is new to our workplace, then the outcome of the learning process will not be known at the outset; there is no expert to tell us what to do and we are creating new knowledge. This is unbounded learning.

The creation of new knowledge is usually a group process and covers all the ramifications of the situation. For example, when commissioning new machinery, the knowledge created is not just about how to operate the machine; it is about operating the machine within the context of the workplace and therefore includes the effect of the new machinery on production schedules, work flow, maintenance procedures and schedules, downstream workers, upstream workers, suppliers, customers, and, perhaps, industrial issues like a drop in overtime etc.

The Applied Technology Framework will entail both bounded and unbounded learning. However, it is the unbounded learning that will enhance

the enterprise's competitiveness and the individual's ability to work at the leading edge of technological development. It therefore enhances the individual's value to the organisation.

The framework

When educators talk of their work, they often use the term 'framework'. We talk of curriculum frameworks, theoretical frameworks, structural frameworks and recognition frameworks. Yet that does not mean we have a clear or shared understanding of what we mean by a framework.

The main objective of this project is to establish a way of accrediting a framework whereby learners have the capacity to access only those parts of the framework they need to have their current competencies recognised. Nationally endorsed training packages form a specification framework which covers the endorsed competency standards for that industry sector (the units of competency), the rules for the award of recognised credentials and the standards governing the assessment processes leading to the gaining of qualifications. These frameworks have now been augmented and given enhanced credibility by the creation of the Australian Quality Training Framework (AQTF). Training package frameworks provide the reference points for our current recognised vocational education and practice within Australia.

Qualifications framework

The frameworks which specify the required outcomes of training under the National Training Framework; that is, the set of all applicable training packages and the Australian Quality Training Framework, are an integral part of the Applied Technology Framework (ATF). However, the evolving Applied Technology Framework is more than just these two frameworks. It will also consist of:

- a nested set of qualifications covering levels IV–VI of the Australian Qualifications Framework. The qualifications, the Certificate IV in Applied Technology, the Diploma in Applied Technology, and the Advanced Diploma of Applied Technology will (it is hoped) be accredited by the Victorian Qualifications Authority by the end of 2004.
- a customised version of the Bachelor of Applied Technology which has been developed and accredited by Unitech in New Zealand with some assistance from RMIT University. The agreement with Unitech enables RMIT University to customise this program and accredit it within the provisions of the Australian higher education sector.
- a graduate certificate and a Certificate III in Applied Technology which is still to be developed. The aim of the graduate certificate credential is to provide a bridge into postgraduate studies and also to enable workers

with other qualifications to access the Applied Technology Framework. It is anticipated that the certificate III will provide an alternative pathway to a traditional apprenticeship in industries with no apprenticeship provision, or act as a bridging program with advanced standing into other apprenticeship programs.

These qualifications and the pathways between them provide an articulation framework which has been designed to meet the possibilities of career pathways for those workers committed to lifelong learning and whose initial training was a trade certificate or equivalent qualification. The research carried out so far for the plumbing, waste management and precision engineering industry sectors show these pathways to be diverse, and characterised by considerable movement between occupational roles. For example, an owner–manager of a small business may be contracted as a part-time paid employee of another business or act in a managerial role for a short time, as the need arises. The career progression of these workers does not follow a hierarchical pathway and is usually opportunistic rather than planned. It does, however, involve the development of considerable competence which crosses industry sector boundaries.

The qualifications and articulation pathways which are currently envisaged for the Applied Technology Framework are shown in figure 1.

Up to this point, the Applied Technology Framework looks like a fairly standard curriculum/recognition framework. After this point, the framework will begin to deviate away from the norm. This is also the point at which a considerable amount of discussion and political activity will be needed if the framework is to serve its intended purpose.

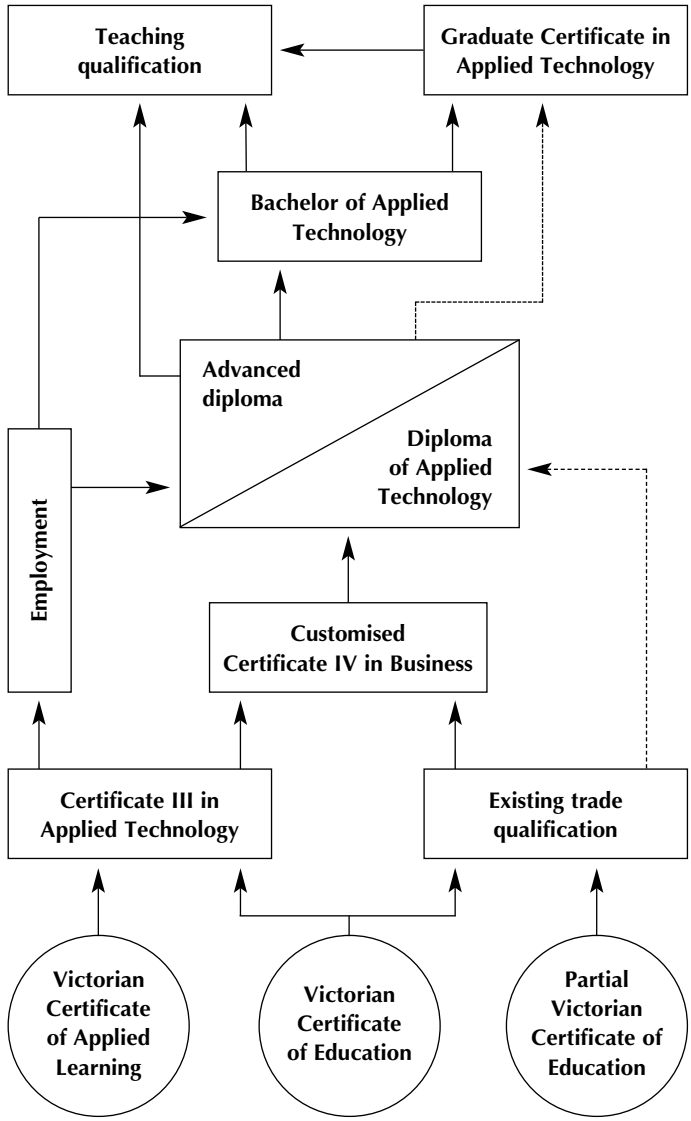
So what other purposes must the framework serve and what additional structures does it need to enable this?

Specification of learning approaches

The Applied Technology Framework has been designed for experienced workers with some pre-entry or co-entry credentials and experience of the nature of work and workplaces, and of different roles within them. Therefore, the framework must be able to recognise the current competencies these workers possess. So the framework must also be a recognition framework.

While there must be processes which enable the recognition of current competency built into training packages and the Australian Quality Training Framework, there is no methodology to enable this to be accomplished. One of the problems consistently noted in evaluations of the recognition of prior learning related to the difficulty and time involved in the process, as applicants for recognition did not necessarily know what skills they had or how to articulate these in the language of curriculum specifications (Wheelahan, Miller & Newton 2002; Bateman 2003; Clayton & McRae 2003).

Figure 1: Planned articulation pathways



Thus the core of the applied technology qualifications must enable people to recognise their current skills and knowledge. This requires the development of:

- the skills and habits of reflection on work
- the ability to assess skills against a set of criteria
- the ability to self-assess progress and outcomes
- the ability to make explicit one's tacit knowledge through group and individual processes.

In addition, the key objective of the Applied Technology Framework is to enable its participants to learn how to approach unbounded learning situations, especially those concerned with being able to learn what is not yet known about technology—and which is probably not yet developed. Most of our current learning theory is specific to bounded learning (Engstrøm 1999). Theories of learning relating to unbounded learning are, as yet, only beginning to be developed. What is clear is that such theories will involve participation in the context where the learning is taking place, such as workplaces, and the ways in which learners utilise the knowledge they gain.

Not all learning methodologies will enable such development. Thus, it is seen as essential that the Applied Technology Framework specifies not only what is to be learned, but also the learning approaches and key strategies to be used.

Such approaches will be concerned with learning through work and learning through, and with, others. Such approaches will thus involve:

- situated learning
- guided workplace learning using both internal and external mentors and facilitators
- investigative and problem-solving learning in the workplace
- group learning and reflection
- individual reflection.

Access to resources

When teachers talk about the need for resources to aid their practice, they are commonly thinking in terms of specifically written learning resource materials or the specialised equipment needed for students to practise emerging skills.

Within the Applied Technology Framework, resources need to be understood in much wider terms. Given both the scope and the work-based nature of the Applied Technology Framework, the development of specifically written resources is both non-cost-effective and not appropriate.

Most workplaces contain, or have access to, a richness of resources for learning where the learning and the work are relevant. Such resources include:

- *Workplace mentors*: such mentors include both formal and informal mentoring. In some instances, some training may be needed to ensure that the workplace mentors understand their roles. Working collaboratively with institution-based learning mentors can achieve this.
- *Standard operating procedures, equipment manuals, and documentation on work processes and procedures*: in workplaces where these do not exist, they can be written by the participants of the programs as part of their learning, and are thus available for future participants.

- *Access to suppliers and other workplace support services and the resources they bring*: working collaboratively with suppliers and other workplace support services not only adds to the richness of accessible resources and the knowledge suppliers bring with them, but it also gives participants one of the strategies they will need to use if they are to continue to keep their workplace competence current.
- *Workplace knowledge and culture*: in any workplace there is a wealth of knowledge about 'how we do things around here'. Much of this is tacit, but good workplace learning can be facilitated in order to bring such knowledge into the explicit domain.
- *Tools and equipment*: having the right equipment is essential for a company's productivity and competitive edge and so workers will learn how to use them through workplace learning if they are to retain their jobs. Thus, facilitated learning with respect to the use of equipment and tools within the workplace should be applied to problem-solving situations so that equipment and tools are used more effectively to minimise waste (of both time and material).

The only resources needed to be supplied by the teachers/trainers are a good understanding of collaborative learning, the ability to adapt to the learners' needs and plenty of imagination and initiative.

Recognition of existing professional courses

A number of industry sectors have access to a wide range of non-accredited professional courses run by professional organisations, trade unions and by vendors and other suppliers to industry. Such courses range from attendance at field days or trade displays to formal programs run over a number of weeks.

Part of the Applied Technology Framework program's charter is to recognise the outcomes of these programs. This is possible by mapping the outcomes of these courses against units of competency within endorsed training packages and, therefore, being able to assess such outcomes directly as recognition of current competency.

Where a course is run regularly, working with the providers of the course will ensure that it meets both the outcomes specified in the training package and the quality provisions of the Australian Quality Training Framework. A registered training organisation may delegate its assessment authority to the providers, and successful participants of the course be given credit transfer.

Recognition of non-training package outcomes

The problematic aspect of recognition under the Applied Technology Framework is the recognition of learning outcomes which are not covered by current training packages or accredited courses. Such outcomes will typically be the results of unbounded learning or bounded learning related to technology

too new or relatively uncommon to have been included in the current versions of training packages.

It is envisaged that this might be achieved by keeping a register of those learning outcomes which are either deemed to be the subject of training package specifications in the future, or those which the enterprises or participants want to have recognised. The register would include:

- specifications of the learning outcomes in unit of competency format
- details of the attainment of these outcomes, including by whom, when, assessors' details, assessment method (which would be available to participants as evidence for credit transfer or recognition of current competency appraisals).

Some of this information could be provided to the appropriate industry advisory body whenever the relevant training package is under review to enable the inclusion of the identified outcomes.

Reality of workplace learning outcomes

Currently, under the Australian Qualifications Framework, the outcomes of learning are presumed to be both hierarchical and uniform within a qualification; that is, all the outcomes of a certificate IV qualification are considered to be more complex than those of a certificate III qualification. When we look at the nature of work and the learning we do through work, this is an unrealistic perspective.

Our everyday learning covers a wide range of complexities, from remembering some fact or a person's name (knowledge), through learning how to use our computers more effectively (application), or identifying potential or emerging problems (analysis), through to designing new processes or resolving system-wide issues (evaluation). We constantly move from simple to more complex tasks and back again.

Thus, when people learn through work (or life), their learning is not neatly packaged into hierarchical or developmental packages. They learn what they need and/or want to learn. Thus, one of the essential components of the Applied Technology Framework is the simultaneous recognition of skills from a range of training packages and a range of Australian Qualifications Framework levels. Workplace learning is multi-disciplinary and of varying complexity.

This means that the Applied Technology Framework must be able to recognise these differentiated learnings without participants having to enrol in a number of different qualifications simultaneously, and thus, possibly, incurring multiple fees and charges. This aspect of the framework, like many other aspects, will need to be negotiated with, initially, the Victorian Office of Training and Tertiary Education, and subsequently, with other state and territory training authorities and the Australian National Training Authority. Such negotiations have begun but are still in an early formative stage.

Summary of the framework

Thus, a key objective of the Applied Technology Framework is the development and establishment of the necessary mechanisms which accredit, or in some way recognise, a learning framework based on current training package outcomes and the Australian Quality Training Framework. It includes:

- specific qualifications
- specified articulation pathways among these qualifications
- specified learning approaches
- suggested learning resources
- provisions for the recognition of professional and other courses/training within the industry area against training package outcomes
- a mechanism for the recognition of non-training package or accredited course outcomes
- an ability to 'enrol' in the Applied Technology Framework rather than in individual qualifications.

Learning approach

One way of visualising the Applied Technology Framework is as a kind of 'Rubik's cube'. While each workplace will have a different configuration of needs and skills, there will be a core mechanism which enables these needs and skills to be configured and applied to form the unique pattern which is necessary for effective workplace practice for that enterprise.

In the Applied Technology Framework, the central mechanism can be understood in terms of organisational, learning and research, and social/work skills such as:

- interpersonal/communication skills
- environmental sustainability
- expansive learning
- imagination/creativity
- design and planning skills
- project management
- finance/business skills
- innovation.

Clearly, these skills and the knowledge which underpins them, cannot be taught in isolation from the day-to-day skills and knowledge which enable us to perform our role in the workplace. However, the emphasis within this learning approach on critical and systematic reflection on work and learning will enable

learners to recognise the embeddedness of these generic skills and to explore how they interrelate with technical and other specific work skills to form a holistic work performance.

The small cubes which form the visible sides of a Rubik's cube can be visualised as different combinations of:

- trade skills
- workplace understandings
- technical skills
- product/process knowledge.

The learning involves the workplace group being supported by learning and technical experts. It is the workplace group who define and understand the problem and systematically seek a solution. The learning and technical expertise or the supporting registered training organisation personnel provide facilitation for this process, and support systematic reflection and the input of supportive but critical outsiders.

The approach is flexible, and current pilot programs being implemented involve a number of different modes, including the involvement of participants within and/or outside work activities and programs in which one enterprise or workplace is involved and those where the learning group is comprised of employees from different workplaces.

Conclusion

The Applied Technology Framework is a mechanism for finding solutions to the current limitations of a training system which is focused on the achievement of predetermined outcomes. Limitations which need to be addressed include:

- qualification rules which:
  - assume that workers require a group of skills, all of a relative level of complexity
  - do not cater for the summative effect of groups of competencies
  - limit the ability of individuals to design skill acquisition programs which meet their work needs and lead to a recognised qualification
- industry standards which:
  - are often focused on past, rather than future, needs
  - appear to be built around concepts of vocations rather than a mix of competencies. An example of this is seen in standards relating to design, project management, finance and management, where the existing standards relate to a role as a 'designer', 'project manager', 'finance worker' or 'business manager' and, therefore, fail to provide for the majority of workers who need these skills as part of a skill package which is focused on a diversity of vocational roles

- failure to recognise that the relative complexity of skills lies as much in the complexity of the context and nature of their application, as in the difficulty of their acquisition. For example, maintaining a cash flow during a game of Monopoly and maintaining a cash flow to keep a small business from becoming bankrupt both rely on the same understandings and a similar level of instability due to uncontrollable contingencies. However, the relative degree of competence required for the two tasks is very different
- a focus on learning what is already known and which can be readily measured or identified. This means that tacit knowledge, the ability to innovate and manage contingency, and the ability to construct knowledge, which are keys to flexibility and 'leading edge' practice, are neither recognised or supported
- lack of recognition of the diversity of outcomes of group learning
- teaching and learning practices which only recognise predetermined learning outcomes.

The current Applied Technology Framework pilot projects being conducted suggest that these issues can be addressed within the framework to enable the specific needs of industry enterprises and workers to be met.

It is not suggested that the Applied Technology Framework will be able to find a universal remedy for all these issues. However, it does promise specific solutions while also providing a mechanism for exploring how workplace learning can be measured in terms of improved practice and against relevant units of competencies, while focusing on resolving workplace needs and issues, and allowing for the uniqueness of each workplace.

The response of government and industry to the framework has been very positive: peak industry bodies have shown interest in, and sponsored the programs, and individual enterprises have indicated their willingness to participate in the project and to fund such participation. One key spokesperson for the precision engineering industry stated:

> *We had resigned ourselves to not being able to access this kind of approach in Australia. The Applied Technology project appears to meet our need for flexible, rapid and proactive solutions for our industry.*
>
> (Spokesperson for precision engineering industry)

One of the key implications of the adoption of this approach is the need to ensure that enterprise projects can be facilitated by training personnel with the necessary knowledge, skills and attitudes. Given the current culture of vocational education and training (VET) across Australia, this is problematic. While there are VET practitioners who have both the competence and attitude to facilitate the project, these practitioners are often not freely available, since their progressive and adaptable approaches make them valuable in a wide range of applications.

One of the solutions to this dilemma currently being trialled within the pilot projects is to staff the projects with a mixture of experienced and not-so-experienced facilitators working in a team. This enables the not-so-experienced practitioners to develop and enhance their skills through participation. This learning through work is backed up at the institutional level by formal and informal discussion and reflection. By using this 'learning through doing' approach to professional development, it is hoped to increase the pool of practitioners who can be drawn on to facilitate future Applied Technology Framework projects.

The Applied Technology Framework project is still in its infancy. There is still much work to be done, especially with government training authorities, to ensure that the framework becomes part of national VET provision and that the achievements of its participants can be recognised within the National Training Framework.

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Innovation at Kangan Batman TAFE

From product development to change management

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In 2002, the Victorian Government announced that Kangan Batman TAFE would house Victoria's new Automotive Centre of Excellence at Melbourne's Docklands. This initiative became a revolutionising catalyst, which set a broad stage for embedding innovation as a core operational philosophy within the institute.

Underpinning the project is a belief that being a truly innovative organisation involves more than simply developing stand-alone products. Creating a positive, flexible and market-focused workplace culture is seen by the institute as a fundamental enabling tool for encouraging the flow of fresh ideas leading to new processes, systems and training products. Kangan Batman TAFE's experience is that systemic innovation is something that can be introduced into the workplace.

Ratio Pty Ltd has developed innovation competencies for the TAFE sector. This chapter identifies some of the indicative initial results from trialling these competencies across the institute's Automotive Group. These range from a new departmental workforce management framework, to surprising attitudinal changes amongst staff. New markets, curriculum, training models and learning resource materials are also being developed as a direct result of the innovation initiative.

With assistance from the Victorian Government's Innovation Fund, Kangan Batman TAFE has extended this model into another business group, as well as expanding it in the Automotive Group by integrating 'employability skills', applied design and project-based learning into the training framework.

Introduction

THERE IS A growing understanding by employers and technical and further education (TAFE) institutes that competitive advantage for Australian industries will increasingly derive from innovation—being able to develop and implement new ideas about how they do business and increase market share. Such productivity growth will occur through industry and TAFE institutes working together to develop and implement new ideas and procedures.

Kangan Batman TAFE in Melbourne believes that being prepared and being willing to do things differently will translate into the attributes that staff, students, graduates and employers increasingly require, such as creativity, leadership, initiative, teamwork, and an enthusiasm to continue to learn.

A key market for Kangan Batman TAFE is Victoria's transport, distribution and logistics sectors, together with their related manufacturing industries. This sector is a linchpin of the state's economy, supporting job creation, growth and global competitiveness by Victorian industry. In 2002 for example, the road, rail, air and sea freight transport and storage sectors contributed over $7.8 billion (around 5%) to Victoria's gross domestic product and employed over 13 000 Victorians.

The Victorian automotive industry is a major sector of the transport industry, and is an initiator in the use of new manufacturing technology and processes. Victorian key vehicle producers, component companies, design houses, toolmakers and other service providers account nationally for:

- 70% of automotive research and development
- 58% of Australia's automotive production
- 58% of total automotive exports
- 67% of all engine and components exports
- 70% of original equipment component production.

However, Victoria's automotive manufacturing industry, like other transport-related industries, faces skill shortages across the board—from production and trades to engineering specialisation, from clerical to senior management. A key reason for these shortages is that the industry is perceived by students and their parents as Dickensian, unfashionable and dirty, a view that is radically wide of the mark, as any visit to a major dealer's showrooms and service areas will demonstrate. In fact, manufacturers such as BMW are developing leading solutions to environmental sustainability issues relating to automobile manufacturing and recycling. An innovation in this area may see manufacturers accepting responsibility for a total recycle of their products, in conjunction with their traditional role as product creators.

Achieving sustainable innovation in a TAFE institute

The biggest challenge for organisations today is to build a system capable of continuing innovation. There are many examples of serendipitous innovation throughout the VET system, examples of achievements in delivery, in technology and in organisational change. However, there are few examples of VET institutions which possess the capacity to deliver state-of-the-art innovation at all levels of the organisation, from the incremental innovations in day-to-day operations, to the revolutionary innovations which produce profit and new paradigms.

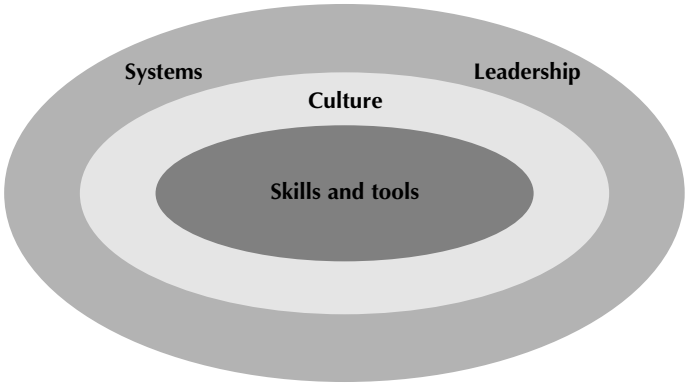
Kangan Batman TAFE set out on a journey to become an institute with the capacity to deliver innovation at all levels of the organisation. With the help of Ratio Pty Ltd and the Innovation Ideas that Work series of resources[1] they had developed, and with the practical experience Dr Ross Bensley at Schefenacker Vision Systems, Kangan Batman TAFE established a trial program of systematising innovative practice and thought.

Much organisational change is an 'outside-in process'. That is, the management puts in place systems, initiatives and so on, which they hope will result in innovation or change. For example, they may start with an ideas box, an ideas competition or a performance management system which addresses individual innovation capacity. This usually fails to produce the desired change because it fails to gain adequate levels of genuine 'buy in' and ownership from the broader workforce.

The Ratio model takes a different approach to building innovation capacity in an organisation. This approach begins with developing the innovation skills of staff diagonally across the organisation. The next step is the development of the leadership capacity and organisational systems required to support the resulting change in organisational culture. Thus, it is referred to as the 'inside-out approach' and is illustrated in figure 1.

[1] These resources, funded by the Australian National Training Authority (ANTA), are the outcome of five years of research and development carried out by the Manufacturing, Engineering and Related Services Industry Training Advisory Board, CREATE Australia and Ratio. They include training and learning materials for trainers, managers, learners and training package developers on core innovation skills, management skills and systems design that contribute to workplace innovation.

Figure 1: The Ratio model for developing an innovative organisation from the inside-out



The steps in the Ratio model—
the inside-out approach to building innovation capacity

1 Start with developing the skills of innovation diagonally across the organisation.

2 Give participants the tools to help them to learn and apply the skills on a work-based project.

3 Provide the leadership demanded by the changed working relationships. Project leaders are identified and coached to develop the necessary leadership competency.

4 Support the culture changes resulting from the training and the project work. In order to practise the innovation competency, it is necessary to be collaborative, to be reflective, to be open, curious and observant.

5 Implement systems to foster the culture, the leadership and the systematic approach to innovation.

Defining innovation

In 2001 Kangan Batman TAFE established an Innovation Unit to encourage the generation, harvesting and testing of ideas in relation to new or improved processes and/or products which would assist the institute in its service delivery.

An innovation incubator and an ideas bank were established, with sufficient project funds to allow key ideas to be developed from a business case proposal to a prototype stage. The methodology used was an industry-based 'product innovation' process which focused on specific, relatively stand-alone projects, using existing creative thinking tools such as Roger La Salle's 'innovation matrix' (2002) and de Bono's 'six thinking hats' (2000).

During this process, two key issues for the institute emerged, namely:

- A focus on individual project development tended to neglect the broader, dynamic and ideas-rich culture prevalent in the education industry.

- ❖ Idea generation and harvesting wasn't the real challenge for the institute; creating an organisational structure which facilitated and promoted new ideas implementation and risk-taking was.

The innovation breakthrough for Kangan Batman TAFE was the recognition that a holistic focus on building staff motivation and an organisational culture to support experimentation without fear of failure, are imperative to business success.

External influences on building an innovation culture

Both the Victorian Government and the automotive industry exerted substantial influence on the establishment of an innovation culture at Kangan Batman TAFE with their expressed desire for a more integrated approach between industry and the VET sector in relation to both education and training and research and development.

Government influence

> *All industry stakeholders recognise that, if the automotive industry, and indeed the manufacturing sector more generally, is to meet the global challenge and prosper in the future, a better and more integrated approach to both education and training and research and development is needed.*
>
> (Allen Consulting Group 2001)

The importance of the relationship between TAFE, industry and innovation was strongly articulated in a statement 'Knowledge and skills for the innovation economy: Future directions for Victoria's vocational education and training system' made by the Minister for Education and Training, the Hon. Lynne Kosky in June 2002. This document has become a primary driver for change in the Victorian VET sector by introducing the concept of an innovation economy, and aligning Victoria's training system to the existing and emerging skill requirements of Victorian businesses. Two key points emerge from this document, both of which directly influence the nature and ongoing formulation of Kangan Batman TAFE's organisation development priorities:

> *The creation and deployment of new knowledge is the key source of comparative advantage for a modern economy. The economic—and indeed social—success of individuals, regions, states and nations is coming to depend on the quality of their human resources: what people know and can do, their creativity, their ability to adjust to change and to innovate.* (Kosky 2002a, p.1)

In effect, the Victorian Government has called on the VET sector to focus not only on the knowledge and technical abilities necessary to perform a set vocation, but also to incorporate learning outcomes which include:

- creativity
- the ability and willingness to accept and respond effectively to change
- innovation.

During 2002, a raft of new industry-focused policies was released by the Victorian Government which continue to have a strong resonance across Victoria's TAFE sector. In particular, the government's new innovation economy policy was set out in the 'Victorian Government innovation statement' (State of Victoria 2002).

In key industry policies such as the *Agenda for new manufacturing* (Department of Innovation, Industry and Regional Development, Office of Manufacturing 2003), innovation, education, training and skills development were highlighted as critical policy delivery tools for the government.

Automotive industry influence

In March 2003 Automotive Training Australia released a 'National VET plan' for the industry (Automotive Training Australia 2003). The executive summary lists a number of key industry issues, which include the following:

- ongoing skills shortages exacerbated by:
  - retention problems in relation to experienced people
  - workforce ageing
  - rapidly changing technology
- the rapidity of technological developments in the industry placing pressure on:
  - the industry to maintain the currency of skills
  - providers, in terms of the capital, human resource and other infrastructure requirements needed to keep pace with technological developments
- the need to consider further industry/provider partnerships
- the need to expand VET activities in sectors of the industry which have experienced low participation rates in the past.

It is clear from both government policy documents and industry research that a traditional, technically based training approach will no longer satisfy employers, government or potential and existing workforce participants. A new learning and training paradigm is required.

Automotive Centre of Excellence

In October 2002, the Hon. Lynne Kosky, Minister for Education and Training, announced a government commitment to establishing a multi-staged Automotive Centre of Excellence at Melbourne's Docklands (Kosky 2002b). While providing a central new campus for Kangan Batman TAFE's Automotive Group, the site will also include university research facilities, other co-operative research centre-related activities, industry professional bodies and a private car museum. The centre will be Victoria's international automotive industry showcase.

This development provided a revolutionising catalyst which established a broader context in which to initiate a pilot change management model across the Automotive Group workplace, while the Docklands site itself provided a timely 'greenfields' site and provided an opportunity for vigorous organisational regeneration.

The opportunity to evaluate and assess current and potential business markets, products, systems and processes, training delivery methodology, and human resource strategies, coupled with innovative purpose-built construction and fit-out for the Automotive Group, and a new community profile, present an optimal success scenario for organisational re-engineering.

Ratio Pty Ltd was already working with the institute on a project funded by ANTA, in which Ratio's innovation competencies in middle management within a training organisation context were being tested. Organisational change in the Automotive Group therefore became the focus for this trial.

Underpinning the project was a belief that, to become a truly innovative organisation, innovation must be viewed as more than the development of stand-alone products. Creating a positive, flexible and market-focused workplace culture is seen as a fundamental enabling tool for encouraging the flow of fresh ideas leading to new processes, systems and training products.

Establishing the pilot

Ratio commenced innovation team-training across the Automotive Group early in 2002, beginning with the middle managers. The first step was engaging senior management, since it was important that senior management was committed to the outcomes and process. Ratio has demonstrated that the innovation process has a dramatic impact on the culture, values and ways of operating in an organisation. If the management team is not open to the challenges which are bound to emerge, the process cannot work. In the case of Kangan Batman TAFE, the chief executive was fully supportive of the project, as were the other executive managers.

Ratio undertook an audit survey to assess the readiness of the organisation to adopt strategies related to innovation and to help identify priorities. The audit criteria were drawn from their ANTA research as well as from investigations into organisational culture, particularly from the Harvard Business School. The audit served to gauge the organisational culture and also to introduce the concepts and language to be presented in the program.

A questionnaire was distributed to approximately 80–100 persons. The 27 respondents had worked at the institute on average 16.8 years.

Results of survey

Ratio concluded that: 'Overall, Kangan Batman TAFE appears to be well positioned for adopting strategies for innovation. There are several areas that demonstrate systems that are well structured to optimise innovation within the organisation'.

The audit also demonstrated that there was a collaborative and detailed strategic planning process in place, and professional development was very active. It also noted that managers recognised the need for innovation and could articulate some of the drivers and barriers to their ability to innovate. In addition, the audit noted that staff are teachers in an industry which thrives on innovation and hands-on learning; staff in the institute also demonstrated that they are imaginative and creative and are willing to implement their good ideas.

A number of issues of concern were also identified in the audit. These included a need to:

- reduce confusion about what to do with ideas generated and how to manage feedback from students, reports or research
- improve support for new ideas once they are developed and presented
- improve relationships between teaching and non-teaching units, other departments, and other campuses, since poor relationships had, in the past, caused tension and barriers to innovation.
- increase morale among staff to reduce resistance to new ideas, such resistance possibly due to 'change fatigue' and continued pressure to learn and manage new training packages, resulting in little time for reflection
- be smarter about the delivery and presentation of new proposals, including addressing upfront potential barriers proposed by other parts of the organisation

Pilot structure

The first step in the strategy was to identify potential areas for implementing significant change in the Automotive Group. Through this process, a range of

issues and opportunities were identified, and subsequently considered, to enable the priotisation of the four most important areas for change/innovation. These were:

- development of an internal/external departmental communications strategy
- examination of effective ways to manage an ageing workforce
- analysis of market potential and delivery options for a new qualification
- development of new markets.

Each priority area for change became a project responsibility for individual managers. Vertical teams were established to undertake project scoping, planning, implementation and reporting. This process was facilitated by training conducted by Ratio on two consecutive days. On the first day the emphasis was on training each team in innovation skills; the second day presented the opportunity for each team to apply those skills to their real project.

Towards the middle of the year another set of innovation teams was formed, each led by an 'advanced skills teacher'. Their role was to develop an innovative training delivery framework for the department, based on an identified set of 18 core industry competencies.

In summary, by the end of the year, 22 innovation teams, each with a specific brief, were operating. All members of the initial four teams were trained in applying innovation skills in the workplace, as was each advanced skills teacher leader of the other teams. Currently all Automotive Department training delivery staff (just over 100 full- and part-time) are involved in an innovation team.

Outcomes

Has a sustainable culture of innovation been created in the Automotive Group at Kangan Batman TAFE? Initial results would indicate that the process has been a success as a result of an enhanced individual capacity for innovation. Moreover, there has been a significant change in the thinking styles of individuals within the division, evidenced by the:

- development of a new workforce management framework for the department
- enthusiastic support from students and staff for the innovative team-based approach to delivery of automotive qualifications
- opening-up of new markets and training delivery options, particularly in automotive component manufacturing and motor sport
- generation of new training models, curriculum and learning materials

- positive and enthusiastic support for an amalgamation of Kangan Batman TAFE's two auto campuses, and their relocation to Docklands as a direct result of the innovation team-based approach.

There have been some surprising attitudinal changes in the division. For example, staff:

- are taking on new roles with significant success
- have moved readily and flexibly between campuses
- have redefined their training delivery modes, work hours and resources as a result of the identification of new markets
- are working with a new set of leaders who have given them a new chance to share ideas
- have a greater customer focus (for example, no longer: '*I have completed* 800 hours teaching', rather: '*my students have* logged results for 10 000 student contact hours').

Critical success factors

Three factors were identified as critical to ensuring successful outcomes in building an innovation culture in the Automotive Group at Kangan Batman TAFE. These include:

- *time* to identify critical constraints and potential opportunities, to reflect on a range of potential outcomes, and to undertake training in innovation methodologies
- *training* in the innovation competencies, including the application of those skills to a real-world problem or opportunity
- *goals*—a sense of what the future could be.

Organisational change context

The driving force behind organisation development at Kangan Batman TAFE is a recognition of the necessity to change in order to meet the new demands posed by the innovation economy, and lead the wider shift to an innovation economy in Victorian industry.

An industrial economy model is the most commonly recognised model of organisational structure in the VET sector, and many of the systems and processes currently in place reflect this. Within this model, division is created between core job duties and such 'luxuries' as innovation. It is recognised that, to overcome this division, a far greater organisational emphasis needs to be placed upon research and information-gathering, as well as upon effective information dissemination. At the same time, it is recognised that individuals

must necessarily have an increased, and greater responsibility for their own knowledge and ideas.

It is imperative that Kangan Batman TAFE develops more effective mechanisms for the deployment of new knowledge and innovation, a requirement which needs to be embedded into the strategic and departmental business planning processes.

In a change management framework, traditionally targeted professional development essentially focuses on new or upgraded skills development. However, in meeting the needs articulated above, Kangan Batman TAFE staff need to:

- have the knowledge and ability necessary to perform their job
- be creative
- be able to change
- be willing and able to innovate.

Innovation is the means of effecting this change. Innovation is concerned with challenging assumptions and creating a space where a greater depth of learning can occur. This sort of learning is more fundamental than learning typified by traditional staff professional development since it concentrates attention on the ability to question, and hence to learn.

Organisation development, in fostering an organisational identity, is responsible for translating the lessons learned in the innovation process into organisational norms. The first step is to embed the notion of reflective questioning and learning into organisational structures, or at the very least, to revise all systems and structures within the organisation which discourage the questioning and reflection which ultimately lead to learning and innovation.

The challenge of innovation for organisation development is to refocus organisational priorities to building staff capabilities in the first instance, rather than imposing an abstract capabilities framework upon staff. In formulating an organisation development model for Kangan Batman TAFE, assumptions were made about the characteristics of organisations, and the role individuals play in them. These assumptions directly inform the short, medium and long-term goals of the organisation. For example, people interact in ways that cannot be reduced to the systemic (within an organisation) or to the binary (between two people), are not delineated by hierarchical structures, and are not predicated on taxonomies (classifications) and value chains (management-reporting structures or silos). Therefore, the existing organisational systems and structures, as exemplified by the preceding, are not conducive to effective communication between people.

The shift to an innovation economy means that the organisational development process begins by seeking to embrace organisationally the natural tendency of people to generate and communicate knowledge and ideas.

Organisational development at Kangan Batman TAFE is primarily focused on breaking down barriers to effective innovation and changeability. These barriers are two-fold: cultural and systemic. Effecting change in this area means balancing both cultural and systemic (structural) barriers.

The current Kangan Batman TAFE organisation development model has short, medium and long-term goals. The short-term goal is to align the natural tendencies of individuals to work both as individuals and as interactive teams, with pre-existing organisational structures and systems. This will begin the cultural shift necessary to facilitate the greater change in an easy and natural way, using already existing structures and a minimum of change. In this way, the natural tendencies of people will begin to be encouraged, without threatening those more familiar with a binary (one-to-one) or traditional industrial structure.

The medium-term goal is to de-prioritise systems and structures in the organisation, re-asserting the notion that systems and structures support people to do what they need to do (people do not support systems and structures). Again, this is more a cultural shift, but with related systemic changes. At this stage, staff will be expected to begin to take greater responsibility for aspects of their jobs formerly depersonalised in systemic structures; and at the same time, management will be expected to move from a supervisory role to an enabling role. By way of balance, the systematisation of aspects of the institute's internal business must be broken down, to help facilitate the work of staff rather than hinder it.

The long-term goal is to re-organise the institute around a more organic model, following complexity theory or Deleuze's rhizome[2] (Deleuze 1993), which breaks almost completely with linear models of process and accountability. This step in the process is largely structural. As a radical reformulation of the organisational structure, its evolution would necessarily take place over a period of years.

The future

The primary goal for organisation development at Kangan Batman TAFE is to encourage the institute's development along two concurrent lines, culturally and structurally: culturally, as a people-first organisation in which systems and processes, structures and hierarchies are all accepted as subsidiary to the people for whom they are set up to enable; and structurally, as a client-focused organisation with a central pool of industry experts, rather than as is currently the case, a traditional industry sector or faculty area (silo) organisation.

The Post Compulsory Education Pathways department of institute operations is an example of a client-focused operational structure. The

[2] A figurative term used to describe non-hierarchical networks.

department is primarily focused on meeting the needs of 15 to 19-year olds in the VET in Schools program. The department's function, operations, networks etc. are all geared towards this particular client group. Teachers are sourced from across the organisation without regard to the traditional industry sector or faculty area boundaries.

It is envisaged that, in terms of its structure, Kangan Batman TAFE will replicate this model across the organisation, with a series of client-focused departments responsible for key client groups, such as apprentices, short-course customers (fee-for-service), enterprises etc. These departments would have responsibility for the profile of programs delivered by the institute, ensuring a client-focused program profile. Current industry or faculty area departments would be expected to reprioritise their focus onto industry-specific concerns, such as networking and forming partnerships with industry clients as industry experts.

At this stage the client-focused groups are far from finalised, but a trial in 2004 will concentrate on the coordination of whole-of-enterprise delivery, a key strategic priority for Kangan Batman TAFE.

Conclusions

Innovation can be understood as a manifestation of entrepreneurship through the development of new products and/or services, and the capitalisation of intellectual property.

The creativity which drives innovation can also be effectively and profitably applied to organisational change, and aligned to change management theory. In this context, innovation becomes a logical departure from and extension of already tried and true systems, such as total quality management and continuous improvement frameworks.

Successful innovation in organisational change requires active and visible senior management support. Confidence must be built throughout the organisation to enable risks to be taken, on the understanding that failure may occur and initial solutions to problems are quite possibly not the best ones.

Time for reflection needs to be part of daily work practice. Managerialism will kill innovation!

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Central TAFE innovation

Positioning a TAFE college in the knowledge economy environment

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Central TAFE Western Australia

This paper provides a case study of recent activities related to innovation at Central TAFE (the largest technical and further education [TAFE] college in Western Australia). In response to recent policy drivers, which highlight the need for innovation within the vocational education and training (VET) sector, the college adopted a strategy for fostering innovation within the organisation.

This strategy involved the development of a conceptual framework referred to as 'Central Innovation', which allows the college to 'test' the value of current and potential initiatives. As a consequence, the college has been successful in increasing its capabilities, creating new business opportunities, improving staff expertise and developing new learning and skill development models. Described here are some of the factors which may help promote similarly successful innovation strategies within the VET sector.

Innovation policy drivers

THE DRAFT NATIONAL strategy for vocational education and training, *Shaping our future*, released by the Australian National Training Authority (ANTA) highlights the need for innovation within the VET sector:

> *The strategy does not apply just to education and training, but to employment, regional development, environmental sustainability, innovation, social inclusion and other portfolios.* (ANTA 2003)

In 2003, the Western Australian Minister for Education and Training released a policy paper, *Creating the future: Vocational education and training priorities 2003 to 2004* (Carpenter 2003). This document highlighted the need for the development of 'an innovation framework that positions the TAFEWA network as the pre-eminent catalyst for economic development'.

'Building future prosperity: Creating jobs and wealth through industry development', the draft Western Australian industry policy statement, released in July 2003, identifies eight industry development priorities for the state, including active promotion of innovation, enterprise and creativity, as key drivers of industry development. The policy defines innovation as: 'the process of turning ideas, knowledge and creativity into new business opportunities or increased productivity through adoption of new technologies, processes and work practices'. The policy notes that: 'all sectors of the economy need to be innovative, including the Government itself', and calls for a greater integration of research, education and business, and greater linkages between education, vocational education and training and the university sectors.

These strategic documents bring together a view of an emerging environment for TAFE colleges which is concerned with:

- new relationships with industry which will extend and enhance the role of TAFE through industry networks and projects
- new relationships with the community which will include the establishment of communities of interest
- a new role for education and training, one which extends beyond the existing training delivery from an institutional base
- a need to encourage and support innovation and engage in relevant research
- a need to promote knowledge underpinning the application of new models to innovation across and beyond TAFE colleges.

Developing an innovation strategy

Central TAFE is the largest TAFE college in Western Australia—its roots extend 104 years back to its origin as the Perth Technical School. The college sees itself as a market leader, with 43% of courses offered at Australian Qualifications Framework diploma level or higher.

As a leader in the Western Australian VET sector, Central TAFE has adopted a deliberate strategy to foster innovation within the organisation. One of the college goals encapsulated in its vision statement is to be 'recognised as an innovative, creative and sought-after deliverer of vocational education and training solutions locally, nationally and internationally'.

Five 'vision drivers' are identified:

- becoming more learner-focused
- closer alignment with our industries and clients
- development of partnerships and alliances

- building an operating culture which is innovative, creative and fulfilling
- operating within a disciplined business framework.

(Central TAFE Strategic Plan 2000–2004).

Aspects of Central TAFE's innovation strategy have received acknowledgement. A review of the Western Australian VET sector (McRae 2001) highlighted the potential of the college's art, design and media and technology training campuses to achieve a high public profile and to become a 'centre of excellence'. Ongoing review of college directions is provided by using 'strategic planning in action' methodology, a methodology which utilises external consultancies, external reference groups and market research. This external input continually propels the organisation forward and avoids an introspective review of college activities.

A 'destination' for positioning the college in the future, 'Central 2010', has been developed. This positioning envisages the college continuing its market leadership role, but by 2010, being transformed into an intelligent, connected VET institution in a 'knowledge economy' where knowledge and information will be the key components—'the capital'. The knowledge economy is defined by the Western Australian Technology & Industry Advisory Council (2003) as the increasing importance of knowledge as a source of value and competitiveness in an increasingly networked global economy.

The challenge presented by Central TAFE's vision and the external drivers and policies such as those outlined above, is how the college can achieve innovation and creativity in a TAFE environment. Given that this environment is characterised by multiple stakeholder expectations, a tight fiscal context, and a culture of traditional thinking and government legal frameworks, new approaches, funding sources and capabilities are required if the college is to succeed. The college executive has confronted the challenge of creating an innovation and creativity strategy in recent years and has established various staff, stakeholder groups and consultancies to seek answers and produce responses, concepts and plans.

Early work to meet these challenges has demonstrated that innovation is already typical of the organisation and its staff, and that numerous 'innovative' activities were ongoing. However, the in-house deliberations and consultancies indicated that no discrete strategies relating to innovation had been established, nor had any suitable definition of innovation or target areas been identified.

It became clear that a more organised approach was required. It also became clear that an organised approach was inappropriate if current innovation interest and current activities were smothered. It was understood that what was required was an approach which supported current innovation activities but facilitated the emergence of new innovation initiatives in a focused way, and linked to college directions and external drivers.

In 2000 the college instituted 'innovation festivals' which lasted several days and allowed staff to showcase innovative activities, developed and occurring at a local level. These were basically a celebration of current successes at the time.

In 2001 the managing director, Mr Brian Paterson, requested the formulation of two strategies and their associated business plans—the Applied Research and Development Strategy and an Innovation Strategy. The Applied Research and Development Strategy was developed by staff members dedicated to the idea of creating a culture of innovation within the college and who took the view that the college could expand activity in applied research and development, and that this growth could result in:

- support of state and national directions for vocational education and training, innovation and research
- the enrichment of the learning experience for staff and students
- the provision of an innovation platform
- the influencing of current expertise in study areas and individuals
- the identification of new technologies and emerging industries
- the diffusion of new technology to industry and the TAFE system
- the development of commercial or business opportunities.

The plan was endorsed by the College Council in 2002. It is still in place and is being vigorously pursued through the Office of Applied Research and Development.

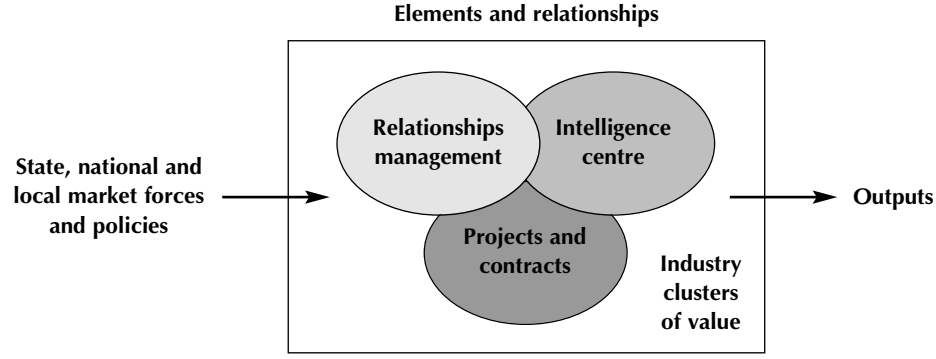
The development of an overarching Innovation Strategy proved more problematic. To prompt college staff to begin consideration of an innovation strategy and all implied by it, the managing director suggested the development of a new strategic initiative in the college. This initiative was designed to locate the college as 'an innovative participant in the knowledge economy. It would be a strategy that exposes our staff and students to the more contemporary issues of the knowledge economy as well as providing knowledge economy linkages to key icon industry players'.

The development of a conceptual framework known as 'Central Innovation' provided the starting point to this journey along the innovation path. The framework proposed a definition for 'strategic innovation' in a TAFE context, suggested a market positioning for Central TAFE in the innovation arena, and recommended that an industry cluster approach be adopted. This industry cluster approach adopted a modified 'Michael Porter approach' (Porter 1998). What Porter calls 'clusters' are critical masses of linked industry entities concentrated in a single location and include manufacturers, suppliers of raw materials and services, and institutions such as universities and government agencies, whose role it is to provide training, research and development and infrastructure for industry clusters.

A series of stakeholder meetings with local business and industry figures, venture capital representatives, entrepreneurs and academics during and after the development of Central TAFE's innovation strategy and a review of successful, innovative, training and applied research and development institutions overseas confirmed that the principles of the Central Innovation framework were sound. The college now had an excellent, local market-tested innovation approach backed up by international contemporary practice in similar institutions.

The key elements of Central Innovation are outlined in figure 1.

Figure 1: Central Innovation



Market positioning

The positioning statement for Central Innovation: 'Strategic innovation for industry' has been defined as follows:

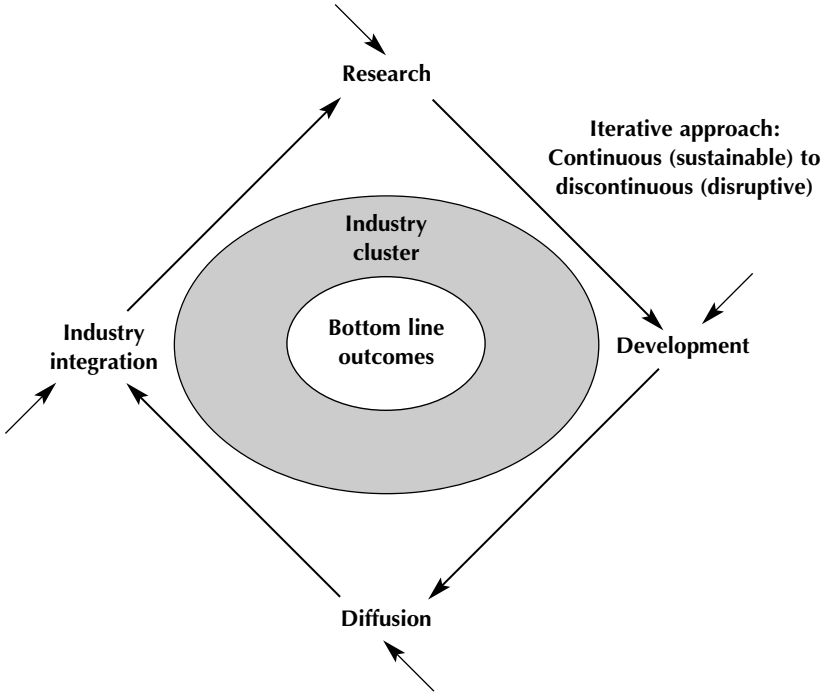
> *Strategic innovation is seen to be a broad process, including foresight, opportunity analysis, applied research and development, technology diffusion and integration by end-users* [industry in the main].

The notion of 'strategic innovation' is both relevant and appropriate to a TAFE college environment. It is unlikely to conflict with university activities in the innovation arena; rather complement them and allow collaborative ventures to develop (Central TAFE 2003).

Current elements of Central Innovation implementation

The creation of the Central Innovation concept and strategy enabled the college to present its current and emerging innovation activities coherently and articulately to both industry and the college. The conceptual framework also allowed the college to 'test' current initiatives for value and fit, provided a capability to add value to current activities, and also enabled the consideration and creation of new projects.

Figure 2: Strategic innovation process elements



The college has initially focused on amalgamating the current innovation elements related to science, technology, sustainability, the resources sector, design, wellness, visualisation and the online environment under the Central Innovation banner. The college has also begun to establish appropriate industry networks as a first step towards the potential development of industry clusters. The college strongly recognises that the formation of industry clusters will require both industry leadership and government agency support, and is working actively with the Department of Industry and Resources and the Department of Education and Training.

The monetary value of the innovation activities is now recognised as an important business asset in the college. Moreover, significant funding towards the innovations is sourced from external sources. Current activities marketed under the umbrella of the Central Innovation framework include the Centre for Online Services which provides online training solutions to industry and agencies. This unit is also conducting developmental projects, such as a pilot study within the VET sector, iLectures, which is a web-based technology which enables students in design, electronics and marine studies to remotely access learning materials. This developmental project has been supported by ANTA, the Western Australian Department of Education and Training, Challenger TAFE and the University of Western Australia. Moreover, the project complements the Liberated Learning project currently being conducted

at Central TAFE, and described elsewhere in this book (Paez, Wilkes & Gurgone 2004).

Another unit located under the Central Innovation banner is KT Studio. This unit was transferred to Central TAFE at the request of the Premier and the Minister for Education and Training and consists of a director and a project-based team of multimedia developers, designers and software and web programmers. The director of the unit has been active in the development of Central TAFE strategies, including Central Innovation and industry clustering approaches, and collaborates with the Central Design Centre. The studio's focus is 'the development of concepts, models and prototype environments which explore the application of new and emerging online technologies and standards to the complex issues and opportunities of the knowledge economy'.

The positioning of the studio within the Central Innovation framework provides a strategic context for a new integrated approach for Central TAFE which is being refined in the context of a number of projects. Conversely, Central TAFE's integrated, strategic response to the knowledge economy provides a coherent framework for the research, projects and direction for KT Studio. In addition, new models for consultation, training and workshops are being developed, along with new approaches to authoring and editing of media of all kinds, from text and voice, to video and still images, 3D models and animations.

The studio is also involved in the development of internal strategies to strengthen Central TAFE's ability to leverage its knowledge internally (Central Knowledge Strategy) and to enhance the college's capacity to deliver services in a contemporary fashion through an appropriate infrastructure (Contemporary Infrastructure Strategy).

Designing Futures is a major project being undertaken in a partnership between the KT Studio and CraftWest to establish a design culture in various Western Australian industries, and is being accomplished through a range of programs which have been amalgamated to establish communities of interest and collaborative opportunities linked by an online space. This complex, knowledge-driven innovation strategy is being implemented for the timber industry. The project involves the development of what is known as 'knowledge space', which is designed to integrate, accelerate and extend the reach of its programs. It will encompass a growing body of knowledge, stories, debate, learning and experience which can be applied to specific aspects of the industry. As an awareness of the impact of good design becomes more widespread, a shared sense of this led to the development of 'communities of interest', clustered through web linkages. Included in these linkages are master classes and mentoring sessions, which are captured digitally for use and reference.

Consideration of the sustainable management of Rottnest Island, an island off the coast of Perth, has presented another opportunity to establish an online environment and which is designed to develop a greater appreciation of the complexity of the island's ecological infrastructure, while enhancing the visitors'

experience of the island. This is just the beginning of a process which will, yet again, establish communities of interest and collaborative opportunities and present multiple views on the complexity of the island.

Also located within the framework of Central Innovation is the Central Design Centre. Launched by the Western Australian Minister for Education and Training, this centre will provide opportunities, through collaboration with industry, for developmental and research activities related to the application of design. Here, design is defined as 'deep design' and embraces engineering, technology, craft and art. The centre will also provide a vehicle for entrepreneurial and postgraduate TAFE students to launch companies and pilot new product development.

The model of learning offered by the Design Centre has been recognised recently in a Western Australian Technology & Industry Advisory Council report (2003) and has been supported by an Innovation Strategy grant from the Department of Education and Training for 2004. KT Studio also uses the facilities of the Design Centre for industry cluster projects related to design, as does the Centre for Online Services.

The Central Innovation framework also encompasses:

- the Complementary Health Centre, launched in 2003 by the Minister for Health, which will provide training in wellness and alternative therapies and pursue relevant applied research and development opportunities through the Office of Applied Research and Development at Central TAFE. The director responsible has established an industry network and is considering how a worthwhile industry cluster can be stimulated
- an industry cluster framework project with the Department of Education and Training and the Department of Industry and Resources. This framework proposed a methodology for defining clusters of value to the state and the participants.
- the Applied Research and Development Strategy. This strategy is the most mature of the college's innovation suite.

The distinction between applied versus pure, or basic, research can be a fine line, often blurred. Pure research is often defined as that which is motivated by curiosity, whereas applied research is undertaken to answer specific questions. The college's exclusive focus on applied research and development ensures compliance under the Western Australian *Vocational Education and Training Act 1996* which states that the college can 'undertake research and development related to vocational education and training which has a direct practical application to industry, commerce and the community'. The focus on applied research aligns with the college's strategic focus on innovation—since innovation is essentially the application of new ideas/the exploitation of invention.

One of the major challenges for the VET sector is ensuring that its research activities are recognised and funded as legitimate contributions to the body of

knowledge that constitutes Australian research. In late 1999, the Western Australian Department of Training, in conjunction with the State Training Board, launched the Science and Technology Innovation Fund. By funding research projects undertaken by VET organisations in collaboration with industry, the fund aimed to develop the science and technology capacity of the sector. This fund provided Central TAFE with the opportunity to launch the Applied Research and Development Strategy and enter the research arena.

In the first year of the Science and Technology Innovation Fund, Central TAFE secured funding for a single project—establishing evidence-gathering systems for forensic science. Two projects from Central TAFE were funded in the 2000–2001 round, with a further two funded in 2001–2002. The projects were highly successful in terms of industry buy-in, impact on core business, and practical, industry-relevant research outcomes. The impact on core business, that of training, was particularly significant. Student participation in the research projects resulted in enhanced skills acquisition and student satisfaction. Furthermore, the projects enabled the acquisition of cutting-edge equipment, and resulted in the development of training materials and resources. The success of the projects fulfilled one of the key objectives of the fund—to promote the VET sector as a 'high tech' training choice, and a key objective of the Central TAFE vision—that the college be an innovative and creative VET provider.

The college has leveraged its growing applied research experience, and its recognition as an applied research player, to enable its participation in a number of major ventures, including:

- the Interactive Virtual Environments Centre: a joint venture with Curtin University of Technology, the Commonwealth Scientific and Industrial Research Organisation and the University of Western Australia, providing high-powered computing and visualisation research and technology diffusion
- the Co-operative Research Centre (CRC) for Sustainable Resource Processing: as a supporting partner in association with industry members such as Rio Tinto and Alcoa
- the federally funded Advanced Materials Technology Network: as the Western Australian hub
- the InnovationXchange, a national, web-based information network for innovation, research and development and education resources as a Network Leader. Funded by the federal government, the InnovationXchange aims to provide a one-stop exchange connecting industry to innovation.
- the inaugural Premier's Collaborative Research project on visualisation related to mining safety, with the University of Western Australia, the Commonwealth Scientific and Industrial Research Organisation and the Department of Industry and Resources.

The formal entry of the college into a co-operative research centre is a first for a TAFE college in Western Australia. In a 'snowball' effect, participation in these ventures has resulted in other benefits, such as the co-location of past industry partners, such as Continuum Resources Pty Ltd, at Central TAFE premises, and participation in additional research collaborations, on and off site.

The initial stages of implementation of the Applied Research and Development Strategy were almost ad hoc as it relied heavily on the expertise and commitment of individual staff members, and accessible, appropriate and timely funding opportunities. However, the college is now in a position to define its research focus based on internal drivers, such as the strategic intent and areas of expertise, and external drivers, such as national and state priorities, and industry strengths. Table 1 lists the defining areas of interest.

Table 1: Areas of applied research and development interest at Central TAFE, 2003

Established areas	Emerging areas	Targeted areas
Sustainability	Materials	Design
(Science)	Manufacturing	Wellness
Visualisation		
Metallurgy		

By identifying specific target areas, and focusing resources to support and expand activity in these areas, the college is able to build expertise and infrastructure, and leverage funds and industry support based on past successes. In addition, the college has developed a reputation for expertise in these areas, which has enabled it to establish and build upon relationships within both the research community and industry.

Success factors

While Central TAFE's innovation activities would be modest by comparison with a major university, in the context of the VET sector, they are a unique achievement and provide a good example of the potential contained within the sector. A series of factors have supported Central TAFE in establishing itself in this arena. These are:

- *Political support*: successive Ministers for Training have supported the college's entry into business arrangements through the *Vocational and Training Act 1996*. Without this support, formalised collaboration in joint ventures with industry and the university sector would not have proceeded.

- *Determination at senior management level*: the personal drive of the Managing Director and the willingness of senior staff have motivated the college and taken it into new conceptual and business territory.
- *Interest of research and innovation-capable staff and students*: although small in number, the college does have a pool of highly qualified research-capable staff who are willing to explore new ideas, engage with industry, take risks and examine ways to feed innovation back into the college's core training business. This group of champions will now be supported by the introduction of a post-doctoral model into the college. Student involvement is also now perceived as crucial in assisting the staff to reach their goals for projects, and is providing benefits and new models for learning in the student body.
- *Focus on targeted areas of strength*: these areas of interest and strength support state and national directions. The college has been fortunate in that a number of its core training areas, such as mining, science and materials technology, have recently become priorities for the state's Science Council (a major funding body). Further opportunities have arisen nationally which matched the college training and expertise base.
- *The active development of networks*: the college has pursued the establishment of strong links to industry, major corporations, government agencies, the Commonwealth Scientific and Industrial Research Organisation and universities. These links now exist at many levels and staff act in both interpersonal and formal capacities through board or committee representation. College staff have developed a personal and professional reputation for 'value adding' to these boards and committees.
- *Planning and opportunism*: the college has adopted a highly planned approach to its innovation directions at a macro level. At a 'project hunting' level, personal contact and networks have led to some unexpected opportunities. Local entrepreneurship is as important as planning in attracting projects and initiatives.
- *Providing an output of value*: while each project pursued through the Central Innovation Strategy of the college is different, none would have proceeded if it were not of value to stakeholders or funding bodies. Careful attention to the 'market value proposition' is required by the college.
- *Sourcing new capability as required*: the college has adopted an approach of 'market and capability scanning'; for example, as noted above, the organisation has recently incorporated a new unit, KTStudio, originally located in another government agency, into the college to build knowledge economy capability. Key researchers and business developers have also been actively sought out by the college to add needed capability.

Conclusions

Taking a deliberate strategy approach to innovation in the environment of the specific sector of vocational education and training, in the context of the 'knowledge economy', and in response to state and national directions for science and technology, has enabled Central TAFE to establish a reputation for value-adding to the innovation activities of both industry and the university sector. The Central Innovation strategy has increased the college capability, created a new business line, imported staff expertise and assisted in the development of new models for learning and skills development. The strategy has also provided an exciting methodology to assist the college to achieve its vision.

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Vocational education and training engaging with emerging technology

The Liberated Learning Project consortium

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This chapter describes an innovative use of speech recognition technology which has assisted students with special needs at Central TAFE in Perth, Western Australia during 2002–2003. The technology and its application to the teaching and learning context is part of the Liberated Learning Project which uses speech recognition technology to assist students with disabilities and students from non-English speaking backgrounds in tertiary lecturing contexts. The chapter first describes the Liberated Learning concept and the origin of the Liberated Learning Project. This project is part of a global consortium which is applying speech recognition technology in learning and teaching environments around the world. It then examines how the speech recognition technology is applied in the learning and teaching context to assist students with special needs, those with disabilities and those from non-English speaking backgrounds in Central TAFE lecturing contexts. It is hoped that, in Central TAFE, this technology will be a stepping stone to enable all students to have equal opportunity and access to pursue their educational aspirations.

The teaching/learning framework within which the technology works to assist students is discussed, and both traditional uses, in terms of content delivery, and more recent approaches, which place greater emphasis on learning outcomes and problem-solving skills, are examined. Finally, the chapter makes recommendations and argues for a re-envisioning of the use of technology, not just as a tool of delivery, but also as part of an approach which provides the lecturer and students with the resources to extend their own knowledge and skill frameworks.

Introduction

THE INCREASING USE of information communication technologies to assist with learning in the vocational education and training (VET) context is becoming increasingly widespread, in line with recognition of alternative

theories of learning and new mandates for inclusive teaching and flexible delivery (Oliver 2002). One such information communication technology, speech recognition technology, is now accepted as an aid to learners with special needs, particularly in one-on-one situations requiring adaptive technology (Marshall 2002). Its application in larger instructional contexts, however, is more recent. In Australia, the Liberated Learning Project investigates an innovative application of speech recognition technology to assist students with special needs, such as those with disabilities and those from non-English speaking backgrounds, in tertiary education lecturing and instructional settings. As part of the global consortium comprising the Liberated Learning Project team, Central TAFE in Perth has, from 2002–2003, implemented speech recognition technology in selected subjects. It is hoped that the use of this technology will be a stepping stone to universal access in Central TAFE to enable all students to have equal opportunity to pursue their educational aspirations.

The Liberated Learning concept

Liberated Learning is a unique application of speech recognition technology as a method for assisting students with disability in the university classroom. In Liberated Learning classrooms, lectures are transcribed in real time using automated speech recognition technology and projected to the class, enabling students to 'see' the lecture. After the lecture, comprehensive, software-generated notes are provided in a variety of forms (Liberated Learning Project 2004).

For more than two decades, the Atlantic Centre for Research, Access, and Support for Students with Disabilities at Saint Mary's University in Nova Scotia has been responding to the needs of students with disabilities. Saint Mary's critically watched the development of speech recognition technology, believing that one day it would revolutionise the learning experience of students with disabilities by assisting with their integration into higher education.

In the second half of 1998, after intensive voice training on computers, three Saint Mary's professors, wearing cordless microphones, utilised speech recognition (voice-to-text) in their classroom for one semester. This brief exposure suggested that it could provide an alternative to conventional note-taking for students with disabilities. Serendipitously, it was also noticed that non-disabled students were using the instantaneous display of the lecture as a reference check of their own notes. Therefore the successful application of speech recognition technology was seen to have valuable applications for all students, giving access to both auditory and visual learning 'pathways', and helping them better integrate the lecture content.

With funding from the JW McConnell Family Foundation, Saint Mary's University and the Atlantic Centre led a global team of university and industry partners in the initial three-year development of the Liberated Learning concept. Called the Liberated Learning Project, this grant began in July 1999.

The main components to the Liberated Learning concept are:

- The instructor develops a personalised voice profile by 'teaching' speech recognition software to understand his or her speech.
- During lectures the instructor uses a wireless microphone 'connected' to a robust computer system running speech recognition software modified for this application.
- This custom software receives digital transmission of the spoken lecture and converts it to electronic text.
- The text is displayed via a projector to the class in real time so students can simultaneously *see* and *hear* the lecture as it is delivered.
- All students have access to comprehensive lecture notes in a variety of formats.

The Liberated Learning Project

The Liberated Learning Project aims to provide students with disabilities and other special needs, such as students from non-English speaking backgrounds, with a tool to enable them greater access to lectures and in-class instruction, thereby 'liberating' their learning options (Leitch & MacMillan 2001). As noted earlier, it does this using speech recognition technology to provide a real-time digital display of spoken lectures/lessons and, from this, online transcripts of those lectures/lessons. The online transcripts then become available to students through the Liberated Learning Project website.

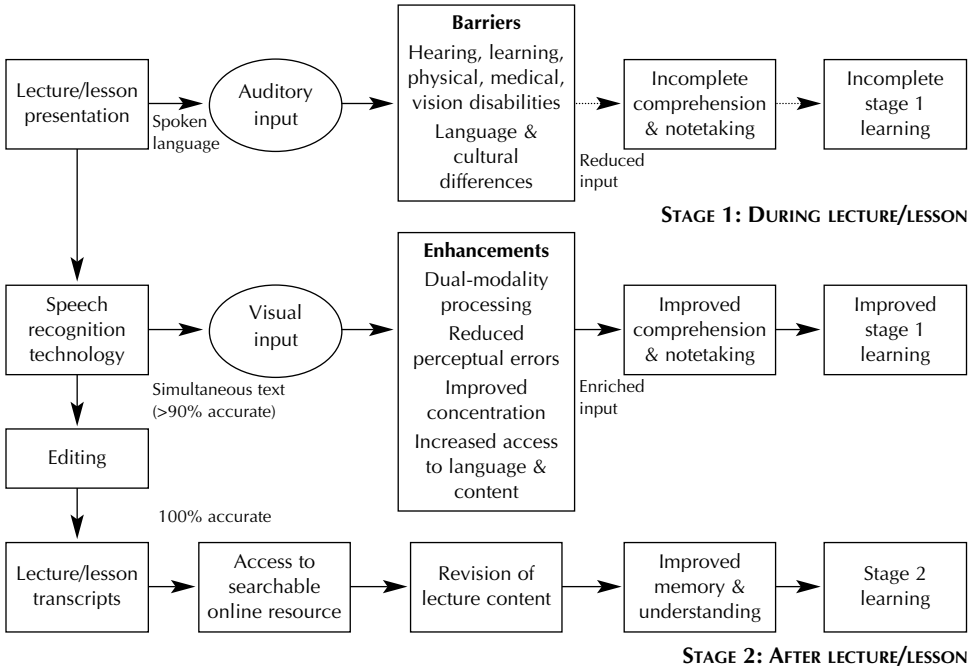
Within the context of an international consortium initiated and spearheaded by Saint Mary's University (Halifax, Canada) in 1998, the University of the Sunshine Coast is pioneering and expanding the use of speech recognition technology in lecture theatres in Australia. Joining Saint Mary's University and the University of the Sunshine Coast, as foundation partners are:

- IBM Research at the TJ Watson Centre, New York
- the Alexander Graham Bell Institute, Canada
- University College of Cape Breton, Canada
- Trent University, Canada
- Cambrian College, Canada
- California State University Northbridge
- Purdue University, Indiana
- Messiah College, Pennsylvania.

These partners, plus associates from the University of Southampton in the United Kingdom and the University of Texas at Austin, continue to collaboratively develop the technology, assess its impact, and drive future applications.

Under the University of the Sunshine Coast's leadership, Liberated Learning in Australasia has expanded to include, in 2002, Murdoch University and Central TAFE in Western Australia and the Australian National University in Canberra, and the College of Education, Albany Campus, Massey University in Auckland, New Zealand in 2003. In Australia, the project is made possible through funding from the Department of Education, Science and Training to establish and support the infrastructure necessary for research and development into the efficacy of this innovative use of technology.

Figure 1: The Liberated Learning Project concept in instructional settings—model of learning support



Source: Hede (2002)

Central TAFE became involved in the project as a result of a presentation at the bi-annual Pathways Conference held in Canberra in 2001. Denny Burns, the Disabilities Co-ordinator at Central TAFE was chairing the session and believed that it would be possible to use this technology to provide greatly enhanced access to students with a disability, since, through the technology, they would be able to gain independence within the classroom rather than being forced to rely on others to provide support by way of note-takers, or where sign language interpreters were not available.

Subjects in which the Liberated Learning Project concept has been used from 2002 to 2003 at Central TAFE include:

- Orientation to disability work

- Communicate appropriately with clients and colleagues
- Contribute to policy development
- Early childhood studies
- Certificate in General Education for Adults—General Curriculum Options for Hearing Impaired (Literacy)
- Advanced academic skills for non-English speaking background students.

Speech recognition technology and the Liberated Learning Project concept

Implementation of the Liberated Learning Project concept in lecturing and instructional contexts at Central TAFE consists of several steps. Upon receiving a laptop computer containing the speech recognition software and its teaching application, lecturers are trained in the use of speech recognition technology. They subsequently create their own voice models specific to their subject area. The training and ongoing development of voice files has an important effect on accuracy levels. As the voice recognition engine learns to make a better match with the speaker's voice and becomes more trained to subject-specific vocabulary, accuracy rates improve.

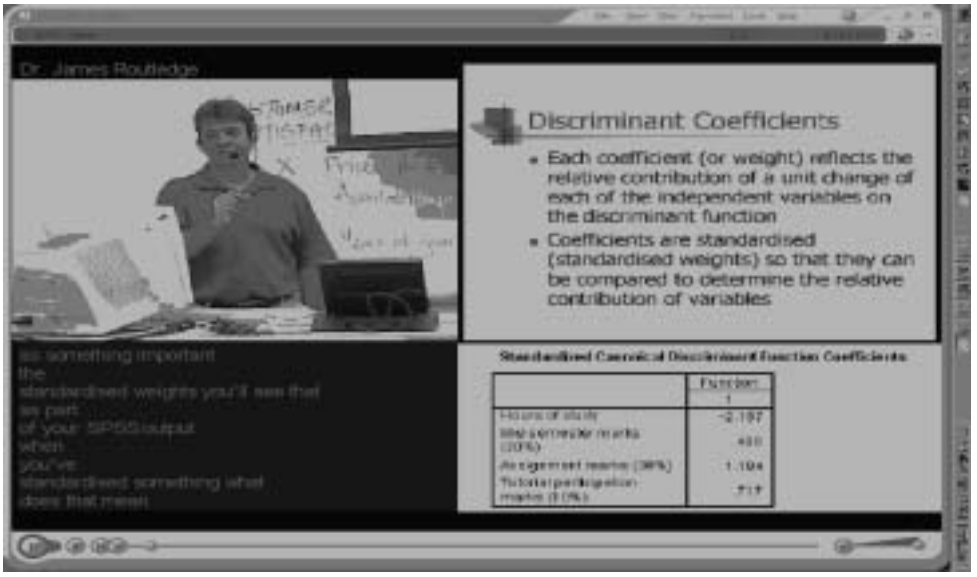
Once in the lecture theatres or other instructional settings, lecturers use the software to project their words, as spoken, in a real-time visual display. This display is projected onto a screen at the front of the room and consists of lines, which scroll upwards as the lecturer speaks. In some subjects the display is shown on a screen below PowerPoint slides and consists of five to six scrolling lines. All students in the lecture theatre or classroom have the option of reading this real-time digitised display of the lecturer's words. At Central TAFE in subjects such as literacy, the digitised display of the lecturer's words is used as an instructional tool as the lesson progresses.

The final step in the Liberated Learning Project concept is the production of the lecture/lesson transcripts, or 'online notes', for student use. Raw files from the lecture/lesson are first proofread by an editor to remove any inaccuracies, and then sent back to the lecturer for revisions as necessary. Finally, the lecture/lesson transcripts are posted on the Liberated Learning Project online notes website for student access. These transcripts are typically used by lecturers as a basis for further instructional activities or by students for review, assignment writing and exam revision. See figure 1 for an overview of the Liberated Learning Project concept and its teaching/learning application.

A more recent application of the technology is the 'workshop module', a task-based workshop using aspects of course content and requiring the use of the student's own content knowledge, experience, and skills. This problem-solving approach leads to the development of new knowledge and skills within

the student's own framework. The 'workshop module' usually consists of a screen divided into sections containing a half-body visual of the instructor speaking, the real time display of the instructor's words, and a series of PowerPoint slides, diagrams, demonstrations, or textbook illustrations. Students may complete these workshop modules individually or in pairs/groups. Programming is currently underway to provide true equal access for all students by enabling them to choose their learning preference by selecting to view all the screen or any combinations of the technology within the screen from audio, video, text, PowerPoint, other software applications (see figure 2).

Figure 2: The Liberated Learning Project workshop module—task-based learning/ workshop format



Increasing access for students with special needs

Students with disabilities are increasingly enrolling in a wide range of VET courses and include those with learning disabilities, hearing impairments, vision impairments, physical disabilities, and medical disabilities. However, they face many challenges in terms of equal access and participation in education and training. VET institutions have a mandate to meet the special needs of students with disabilities and this has been traditionally done through specific subjects, the use of learning support services, scribes, note-takers, interpreters, counsellors, special exam conditions, physical aids, and adaptive technologies.

Students who are physically unable to write find that the speech-to-text nature of speech recognition technology allows them to dictate their assignments and notes. Studies conducted on the use of speech recognition

technology for assisting students with disabilities to write show that such students were able to write longer and more complex sentences with fewer errors (Forgrave 2002; Higgins & Raskind 2000). This is believed to be because students attend more carefully to what is being written and, as a result, are able to read, organise ideas and write more clearly.

Students from non-English speaking backgrounds experience difficulties in coping with the demands of the formal lecture situation and, at times, in the classroom instructional situation. These students must cope with the process of listening, reading and writing in a second language. Listening in itself is a complex and active process, but students must also read PowerPoint slides or other information and, if appropriate, write their own notes. In short, second language students must be able to recognise and understand: the lecturer's accent and pronunciation; stress and intonation patterns; pace of delivery; new lexical items; lexical density; discourse organisation; emphasis and important information; incomplete sentences in PowerPoint slides; abbreviations and shortened word forms (Allwright & Bailey 1991; Clerehan 1995; Nunan 1989).

Processes in second language comprehension are slower and more cognitively demanding (Merlet 2000). Students tend to focus on more surface/literal information, to the detriment of deeper comprehension. Within the Australian Liberated Learning Project delivery, non-English speaking background students found that the real-time digitised screen in the lecture theatre and classroom setting helped them to cope with this cognitive load by:

- providing a visual support to the rapid pace of content delivery
- assisting with unfamiliar vocabulary by allowing them to match the spoken and written word
- allowing them to locate various elements of the presentation and to track the links in meaning and argument
- assisting with note-taking by providing vocabulary, proper nouns and added detail support
- allowing students, through the transcripts, to process information in their own time to assist with deeper comprehension.

In the context of all students, it is important to consider the importance of cultural inclusivity in the design and delivery of learning resources (McLoughlin & Oliver 2000; Reeves & Reeves 1997). For culturally diverse students, this is particularly so. The social and cultural elements of tasks, communication and the structuring of information all need to be considered (Branch 1997; Bork 1991). In the Liberated Learning Project concept, the students found speech recognition technology helped meet this need by:

- assisting with unfamiliar accents by enabling a match between the spoken and written word (even students with reasonable proficiency found this helpful on first arrival in Australia to study)

- providing a written transcript with the audio file of the lecture, enabling students to listen to and read the lecture again if needed
- providing a model for pronunciation and the practice of stress and intonation patterns (oral language practice)
- comparing spoken and written texts; for example, examining the structure of spoken English and the way it differs from written English.

To date the only research conducted on the application of speech recognition technology in lecturing and instructional contexts has been through the project itself (Leitch & MacMillan 2002, 2003). Major findings of the Liberated Learning Project for students with disabilities and their use of the real-time digitised screen display is summarised in terms of positive uses, indifferent responses, and conditional and negative responses (related mostly to adjusting to errors in the text) (Leitch & MacMillan 2003).

To assess the efficacy of speech recognition technology as a learning and teaching tool at Central TAFE, the experiences and views of lecturers, students with disabilities and students of non-English speaking background were canvassed. Semi-structured interviews were conducted with individual lecturers, students and focus groups from these target groups. A qualitative research method (Glaser & Strauss 1967; Miles & Huberman 1994) was used to reveal the depth and variety of participant responses to the Liberated Learning Project concept—their experiences, perspectives and motivations.

This research revealed that students with a disability found the Liberated Learning Project concept useful in diverse ways. Responses from students who are profoundly deaf or hard of hearing show that they tend to rely heavily on the real-time screen display of the lecture, feeling it gives them independence in their understanding of and note-taking for the lecture. Students with dyslexia reported finding the screen display useful for listening and writing at the same time, listening to detail and remembering lists, and matching the spoken word with the correct spelling. Students with vision problems in the low literacy classes at Central TAFE found the screen a positive aid. The instructor displayed the text and screen in pink/purple colours, enabling these students to see the text more clearly than they had if normal text colours had been used. Students with medical disabilities had mixed reactions to the screen display and online notes. Students with chronic fatigue, for example, found both the screen and online notes useful, allowing them to compensate for missed material. Other students whose disabilities did not affect their concentration used the screen and online notes to differing degrees, depending on their need for extra support, their learning styles, and the accuracy of the screen display. If a student's physical disability made it difficult for him or her to write or to keep note-taking pace with the lecture or lesson, they tended to make good use of the screen and online notes.

The research also found that about half of the non-English speaking background students in a class where a Central TAFE lecturer used the speech

recognition technology to deliver lectures believed the technology beneficial for missed points in the lecture and for new vocabulary. They also found it fun to watch and have requested it in future subjects. However, the other half of the class found it less beneficial—these were African students from a traditionally oral culture and found the amount of text constantly on the screen too much.

According to the interviews overall, many factors affected the frequency and intensity of students' use of the screen and online notes. These included the student's level of proficiency in English, degree of comfort with the subject, level of unknown vocabulary, learning style, confidence in own ability to cope with linguistic demands, confidence in managing own learning, and ability to cope with errors in screen text. Levels of accuracy were particularly important for non-English speaking background students—too high a level of error adds to confusion for the student.

It is a goal of the project at Central TAFE to promote more meaningful problem-based learning in the design of tasks. In this way all students would benefit, not just those from a non-English speaking background. Moreover, increased social and communicative collaboration among students in the speech recognition technology environment would result. To achieve this, 'workshop modules' could be developed which require students to work together to access information from different sources and to prepare a joint project or report.

Challenges for the future

The international Liberated Learning team continues to research and develop the use of speech recognition technology in the classroom, primarily focusing on:

- increasing recognition accuracy
- improving user-friendliness
- improving process for software generated notes.

(Liberated Learning Project 2004)

In addition, the readability of text is important and so a readable passage must include sentence markers: punctuation, capitalisation, paragraphs etc. The challenge was to find a non-intrusive way of integrating these markers to enhance readability and thus comprehension. Working with IBM Research, a new classroom application was developed for those involved in the Liberated Learning Project. The lecturer's pause at the end of each thought, making a break in the text and resulting in the display of more readable text, has now been integrated into the technology. There are many other challenges to be faced in relation to making the technology into a robust system for the classroom. These include developing associated technologies, such as the sound card, operating system, microphone technology, memory, storage etc.

Another major area of challenge is concerned with changing the lecturers' overall teaching approach so that they utilise the technology to produce the new

learning outcomes expected of more active approaches to teaching and learning. As Bensen et al. (2002) comment about the use of new information communication technologies in the education context, it is not just the technology but also the pedagogy which needs to be addressed: '… we should not be surprised to find that there are no significant effects on student outcomes if we use digital technologies in ways that do not change the processes or structures of learning' (p.9).

Lecturers need to face the challenge of designing the teaching and learning process to meet the needs of diverse learners while still providing sufficient content. In the traditional lecturing and tutorial format used in universities, the pedagogy focuses on learners as passive participants in a teacher-centred environment and pays only lip service to the idea that real learning involves a change in the learner's conceptual understanding (Ramsden 1992). On the other hand, new approaches emphasise that: 'the results of learning can not be separated from how learning takes place' (Gruba & Lynch 1997, p.2) and comes through interaction, cognitive puzzlement, social negotiation and reflection. Learners learn best through the active construction of knowledge (Duffy & Cunningham 1996) with a focus on the process of learning, not only the product (Berge 1998). Such approaches, often termed *constructivist approaches* or *problem-solving approaches*, place more emphasis on learning outcomes, and the acceptance of diversity among outcomes for learners.

In the traditional lecturing context, information communication technologies act as a tool in the flexible delivery of content. The learners listen to the lecturer and may choose to reinforce this by looking at the PowerPoint slides and/or looking at the real-time display of the lecturer's words through the speech recognition technology. The technology serves to display and reinforce the content of the lecture, an important supplementary aid for students with special needs. However, it must be said that, in some ways, the use of the real-time Liberated Learning Project display suffers from the same criticisms aimed at the use of PowerPoint slides (see for example Brabazon 2002; Brown 2001). At times it is seen as facilitating the passive transmission of content to the learner, rather than encouraging tasks, which require the active construction of knowledge and skills.

In recognition of this issue, the Liberated Learning Project has focused on ways to assist in enhancing skills and the active application of knowledge for the learner. Importantly, this must be done in a way which also supports the lecturers, rather than adding to their teaching loads. To date, this has been implemented at Central TAFE in two ways.

First of all, in the lecturing context, the speech recognition technology has been used in special applications, such as with low-literacy classes or deaf/hard-of-hearing classes. In these contexts, the lecturer uses the screen as a teaching tool in itself. In the low-literacy classes, as the lecturer speaks, the words appear on a centrally displayed screen. The lecturer pauses at strategic

points and teaches directly from the screen, capitalising on the immediacy of the text as it appears and engaging the learners in the negotiation of sound and meaning. In the class for deaf/hard-of-hearing students, an interpreter works alongside the lecturer and the screen allowing the students to see the match between the signed AUSLAN language and the text in a meaningful way. This is particularly useful for students whose first language is AUSLAN and who need to learn English and English literacy skills. For both of these instructional applications of the Liberated Learning Project concept, the teaching and learning process is active in terms of the involvement of the learner in the process of negotiating and making meaning. To set the learners tasks based on these applications would further enhance the learning process.

The second way in which the Liberated Learning Project has been implemented at Central TAFE is through the creation of 'workshop modules' in which the lecturer sets the students a problem for a project or assessment. As mentioned earlier, the problem uses the course content, discussing related/useful areas and pointing them towards possible resources. The students access a module as a file which opens to a screen divided into four sections:

- a view of the lecturer speaking about the problem/task
- the PowerPoint slides giving an outline of the lecturer's talk
- the real-time speech recognition technology display of the lecturer's words to assist those with special needs
- a graphic illustration of a section from a textbook or other resource (see figure 2).

This task may be completed individually, or in pairs/groups so that students may benefit from collaborative learning (see Vygotsky 1978 on the importance of social interaction in meaningful learning and cognition, and Kellogg 1999 on the importance of developing a learning community among students). The aim of the module is to set a learning task that engages the student in the meaningful application of skills and knowledge, and encourages a more proactive learning community among students if appropriate).

Conclusion

As part of the global consortium which comprises the Liberated Learning Project team, Perth Central TAFE in Western Australia has, from 2002–2003, implemented speech recognition technology in selected subjects. The use of this technology in the lecture and classroom setting at Central TAFE during this time has proved to be an innovative way of providing true universal access for students with special needs, particularly students with disabilities and non-English speaking background students. Students now have access to a range of multimedia material which provides all students with access to video, audio,

text, PowerPoint and other software packages which can be accessed either individually, or in any combination, depending on their learning preferences.

The use of lecturer and student interviews provided an information-rich view of the advantages and special challenges presented by the use of the speech recognition technology.

Perhaps the most innovative aspect of the use of the Liberated Learning Project concept at Central TAFE has been the way it has encouraged a rethinking of the teaching and learning context. To meet the variety of needs of the VET context, its diverse subject areas and clientele, a more task-based constructivist approach becomes necessary. Learning is not just about content, and technology is not just a tool for content delivery. Learning is an active, constructive process and the speech recognition technology can become part of an approach providing the lecturer and student with the resources to extend knowledge frameworks.

The need for closer research on the effect of the Liberated Learning Project concept on the teaching and learning environment at Central TAFE is strongly recommended. Findings indicate the importance of research on:

- differences in the needs and uses of the Liberated Learning Project concept for students with disabilities, students of non-English speaking background and general students
- the ways in which the Liberated Learning Project concept can facilitate the development and use of a more constructivist or problem-solving approach to the teaching and learning process—in the lecturing context, classroom instructional context, and through workshop-based modules
- the Liberated Learning Project concept and its role in the new ways of making meaning through an intertextual and non-linear approach to learning—in teacher practices, and in student meaning-making through texts and student interactions
- learning styles and their interaction with the technology as important factors affecting student use of the technology
- note-taking and the Liberated Learning Project concept—its efficacy in reinforcing lecture content, providing extra detail, and assisting students with their own note-taking.

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