

Fostering enterprise: the innovation and skills nexus – research readings



NATIONAL CENTRE FOR VOCATIONAL EDUCATION RESEARCH

Editors

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NCVER



Australian Government

**Department of Education, Employment
and Workplace Relations**

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Edited by
Penelope Curtin, John Stanwick and Francesca Beddie
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The views and opinions expressed in this document are those of the
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About the research



Fostering enterprise: the innovation and skills nexus—research readings

Editors: Penelope Curtin, John Stanwick and Francesca Beddie, NCVER

The main interest in ‘innovation’ is in terms of what it is seen to contribute to productivity at the enterprise level, and to economic prosperity at the national level. Innovation, as we think about it now, is much more than activities related to research and development. Indeed, much of innovation can be thought of as being incremental in nature, and includes improvements to processes.

This book of readings on innovation was commissioned by the Department of Education, Employment and Workplace Relations (DEEWR) and looks at the relationship between skills, innovation and industry. In November 2010, NCVER held a forum in Sydney on the relationship between innovation and skills which explored many of the concepts addressed in this book of readings. Other researchers in the area have also contributed to chapters in this book.

The authors offer a variety of views on innovation and its relevance. While the authors view innovation from differing perspectives, they all implicitly acknowledge the importance of innovation to productivity. We hope that the chapters will stimulate debate about the role of education and skills in innovation, particularly those emerging from vocational education and training (VET).

Tom Karmel
Managing Director, NCVER

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Contributors

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Francesca joined the National Centre for Vocational Education Research in August 2007 and was appointed General Manager, Research, in April 2009. Francesca has a particular interest in the intersection of research and public policy, a topic on which she has written.

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Ludger Deitmer works as a senior researcher at the Institute of Technology and Education, University of Bremen, Germany. Since 2003 he has been the convenor of the European research network for technical and vocational education and training (TVET) of the European Educational Research Association. He is also an active member of the international network for innovative apprenticeships. Ludger has a degree in electrical engineering and in TVET teacher education. His PhD thesis focused on the management of regional innovation networks. He has coordinated and evaluated numerous pilot projects in TVET, with a focus on new learning concepts in workplace learning. He has published several articles on these issues and on the relationships between TVET development, workplace learning and innovations in work organisations.

Peter Fieger is a Senior Research Officer at NCVER, where he has worked since 2009. Prior to this he worked at Statistics New Zealand and at various tertiary institutions. He has published papers in educational statistics. His main interests include quantitative research methodology and survey statistics.

Roy Green is Dean of the Faculty of Business at the University of Technology, Sydney. He is a graduate of the University of Adelaide and has a PhD in economics from the University of Cambridge. He has published widely on innovation policy and management and has worked with universities, business and government in Australia and overseas, including for the OECD, the European Commission and Enterprise Ireland. He is Chair of the Australian Government's Innovative Regions Centre, is on the CSIRO Manufacturing Sector Advisory Council and the NSW Manufacturing Council and is a member of TVET and the Enterprise Connect Advisory Council. He led Australian participation in a recent global study of management practice and productivity for the Department of Innovation, Industry, Science and Research.

Tom Karmel has been Managing Director of NCVER since 2002. Prior to this, he held senior appointments with the federal government in education, employment and labour market research and with the Australian Bureau of Statistics. He has an interest in the labour market and the economics of education, focusing on empirical modelling, with a particular interest in performance indicators in higher education and VET. He has an honours degree in mathematical statistics (Flinders) and a Masters of Economics and doctorate from the Australian National University.

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Josie Misko is a Senior Research Fellow at NCVER. In her 17 years with NCVER she has researched a wide range of issues of national importance, including past and current reforms in the Australian VET system. She has also participated in national and state-based reviews of the VET system's policies and practices, the most recent of which were concerned with the adequacy of current strategies to meet the needs of the twenty-first century, how the VET system (especially training packages) responds to current skill demands, and the extent to which it is able to deliver industry skills for innovation.

Josie has also collaborated on international comparison studies with researchers from NCVER's sister organisations in China (CIVTE) and Korea (KRIVET). She has been the lead researcher for two Australia country background reports for the OECD, one on training for adults with low basic skills and the other on the recognition of formal and non-formal learning.

Lisa Nechvoglod is a Research Fellow at NCVET, where she has worked for five years. Of the many different projects in which she has been involved, a particular research interest is the relationship between equity groups and VET and the role of VET as a second chance. Recent work includes *Vocational education and training and people with a disability: a review of the research* and *Hard to reach learners: what works in reaching and keeping them?*. Lisa has also contributed to a review of the Productivity Places Program for the Department of Education, Employment and Workplace Relations and developed a wiki with information on Indigenous people and VET and people with a disability and VET.

John Rice was appointed Chief Researcher at NCVET in 2010. Prior to this he worked in academia for more than 15 years, most recently as Academic Director – Research Development at the University of Adelaide Business School. He is co-author of two text books in the field of strategic management and has authored more than 30 refereed journal articles in the management and innovation areas. His PhD, investigating strategic alliances, was awarded by Curtin University and he has other postgraduate qualifications in economics, business administration, finance and education from Griffith University, QUT and the University of Adelaide.

David Rumsey was an electronics engineer in the manufacturing industry for 11 years before commencing a 40-year involvement in VET as a teacher, course designer, policy analyst, TAFE executive and training and development consultant. Since 1992, David has provided research and consultancy services to industry, training institutions, skills councils and government and has been an active contributor to training reform in Australia. He is a Fellow of the Australian College of Educators and in 2006 was made a Member of the Order of Australia for service to education and training.

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John Stanwick is a Senior Research Fellow at NCVET, where he is responsible for designing, developing, conducting and reporting research of relevance to the VET sector. At NCVET John has undertaken numerous research and consulting projects in the areas of lifelong learning, apprenticeships, workplace learning, the changing nature of the VET workforce and the outcomes of qualifications. Most recently he has been involved in a suite of work on innovation in enterprises and what it means for the VET sector and government.

Prior to joining NCVET in 2002 John was primarily involved in research and consulting, mainly with the Australasian Centre for Policing Research, the University of Adelaide and Flinders University, and lecturing in management at the University of Canberra.

Phillip Toner is a Senior Research Fellow in the Centre for Industry and Innovation Studies at the University of Western Sydney. His major areas of research interest include: industrial structure analysis; industry policy; the economics of technical innovation; labour market analysis; and comparative national skills formation systems.

Prior to entering academia in 2002, he was extensively involved in program management and research in public sector VET institutions, economic analysis in the federal Treasury and private consulting. He has undertaken research for international organisations, including the OECD, World Bank, ASEAN and Industry Canada. He has also undertaken work for NCVET, the NSW Board of Vocational Education and Training, the NSW TAFE Commission, the Department of Innovation, Industry, Science and Research, the Department of Education, Employment and Workplace Relations and for private sector organisations, including the Australian Industry Group,

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Tim Turpin is a sociologist and Professorial Fellow at the Centre for Industry and Innovation Studies at the University of Western Sydney. He is a science, technology and innovation policy analyst with a particular interest in the local and global processes through which knowledge is produced, managed and diffused. He has carried out field work and published widely on science and innovation systems, research culture, institutional change, and research policy in Australia and throughout the Asia-Pacific region, with a particular focus on South-East Asia.

Overview

Penelope Curtin and John Stanwick
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This opening chapter gives an overview of the various perspectives on innovation proposed by the contributors to this volume, their assessment of the effects of innovation on economies/firms/skills and their views of the issues at the forefront of the innovation debate. The chapter also examines how the various contributors envisage the role of skills, including those imparted through the training system, in supporting and facilitating innovation.

In 2004 the National Centre for Vocational Education Research (NCVER) published a collection of research readings exploring the relationship between the vocational education and training (VET) sector and innovation (Dawe 2004). Not surprisingly, in the intervening six or so years a great deal has changed. The world has weathered (with varying degrees of success) the Global Financial Crisis (GFC), an event that has prompted a re-evaluation of global economies, which in turn has forced countries to look at improving economic productivity. One of the tools that Australia has adopted to lift its economic performance is innovation—Schumpeter had already seen innovation as a means for improving productivity in the 1930s. Even before the rumblings of the GFC, the federal government commissioned a review into Australia's innovation system (Cutler 2008).

Now, at the end of 2010, NCVER has taken another look at innovation—not quite in the same way as six years earlier. This time it is the triangular relationship between skills, innovation and industry that was the focus of work commissioned by the Department of Education, Employment and Workplace Relations (DEEWR) and presented, along with other research at a forum, *Fostering enterprise: the innovation and skills nexus*, held in Sydney in November 2010. Many of the speakers at this forum contributed chapters to this latest book of research readings; other chapters are from NCVER researchers working in the area. While the contributors offer a variety of views on innovation and its relationship to skills and enterprises, these are but a few views—an eclectic collection, if you like, but with some unifying threads and themes—and we are certainly not claiming that this is the whole picture. Nevertheless, this collection of papers moves beyond standard views of innovation and should prompt thinking in areas such as the sociology of innovation and the role of neuroscience in innovation.

What is innovation?

'Innovation' has shown itself to be a slippery construct—in fact, chameleon-like, adapting its meaning according to time, place and economic circumstances, and who is defining the term. In 2004 Dawe and Guthrie defined innovation as ranging 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 [and] is useful to the community in which it is applied' (Dawe & Guthrie in Dawe 2004, p.18, their emphasis). Stanwick and Beddie in their chapter in this current volume note the amorphous nature of innovation, confirming that it means different things to different people, reminding us that innovation used to be equated with invention and was largely centred on research and development (R&D). Indeed, Guthrie and Dawe in their overview chapter in the earlier book of readings comment that, while the contributors to their volume have moved away from the notion of 'innovation as invention', the government of the day had not: 'Australian Government policy to date has focused on the high-profile innovations as represented by the cooperative research centres' (Dawe & Guthrie in Dawe 2004, p.10). As most of the contributors to this volume emphasise, this still holds true, but it no longer represents the entire picture and policy-makers need to think more broadly.

The Australian Bureau of Statistics (ABS) has already done so: it now defines innovation as 'The introduction or implementation of a new or significantly improved good or service; operational processes; organisational managerial processes or marketing method' (ABS 2009), although as Misko and Nechvoglod argue, innovation should not be conceptualised as something *completely* new since we'd be hard pressed to find such a thing: it is 'more fruitful to think of innovation as something or some activity that is either new to the firm itself, or expands or enhances some traditional product, application or practice'. The chapters by Agarwal and Green, and Toner reference the Organisation for Economic Co-operation and Development's (OECD) *Oslo manual* (2005, p.46) for the definition of innovation they use, and on which the ABS bases its version: 'The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations'. Toner's chapter draws our attention to the inclusion of the concept of organisational improvements in the definition of innovation—an indication of the recognition of the 'momentous role' of organisational improvements in economic development, a sentiment emphasised by Agarwal and Green in their chapter.

Toner's examination of innovation describes the two broad types of innovation and the relative importance of each. The first, *radical* innovation, results in 'major technological, economic and social change', which is generally the consequence of significant government investment in science and R&D; the second, *incremental*, results from ongoing minor modifications and changes to an already existing product/process. According to Toner, the innovation literature considers incremental innovation to be the chief source of productivity growth. (The chapter by Dalitz, Toner and Turpin describes an industry where innovation occurs incrementally—the solar industry.) Rice alludes to some innovation research literature as conceptualising innovation as a linked chain of activities, whereby firms source the knowledge required for innovation, 'transform this knowledge into new products and processes, and then exploit their innovations to generate added value'. Rice describes innovation as an iterative process, whereby 'basic research and invention, improved operational and organisational processes and improved methods of marketing' are concurrently integrated. Agarwal and Green note that at the level of the firm most innovation is incremental, although the cumulative effects of these improvements are ultimately substantial.

Why do organisations/firms/enterprises innovate?

Definitions of innovation are tied to the reasons for innovation in the first place, and in reality this is a richer area for investigation, and one where a number of conflicting perspectives come to the fore. In the opening paragraph of this paper we made the sweeping statement that innovation is widely recognised as promoting productivity—at the enterprise and, ultimately, the national level, a point also made in the 2004 NCVER research readings on innovation. This perspective is not universally supported in this collection of essays, although it appears to be the majority view. The strongest case for a causal relationship between innovation and productivity is put by Agarwal and

Green, who argue that Australia's commodity boom 'has masked a structural deterioration in the economy's productivity performance' (the GDP per capita rank has dropped three positions in the last decade), which has implications for the country's future prosperity. These authors contend that productivity is driven by five drivers, one of which is innovation. In this context they draw our attention to the 2009 report, *Powering ideas: an innovation agenda for the 21st century*, which, like the OECD definition given above, recognises the crucial importance of organisational innovation. Organisational—or managerial—innovation is, they posit, the key to Australia's future competitive advantage; put simply, 'new and innovative ways of working provide a source of efficiency gains'.

Toner for his part sees a strong relationship between innovation and productivity and financial performance, citing a 2007–08 figure of 38% of innovating businesses in Australia reporting increased productivity over the previous year compared with 18.7% of non-innovating firms, with concomitant profitability gains of 38% and 26% respectively. Toner agrees about the importance of organisational innovation, but to this he adds technical innovation, arguing that, in combination, these are the major sources of productivity improvement, 'and productivity gains are the principal source of increases in real income per person'. John Rice poses the question of why enterprises innovate slightly differently: he asks why innovation matters. Rice argues that, despite the economic uncertainties generated by the GFC, the world economy over the last two decades has experienced a long and sustained period of economic growth, which has facilitated some degree of prosperity in societies, notably in Asia. To this he adds a second point: it is now generally understood that, as he puts it, 'there is a limit to an economic growth paradigm that relies on the consumption of finite resources in an unsustainable manner'. Rice argues that these two factors point to the necessity for maintaining economic growth with all its social ramifications, while recognising the importance of sustainability and diminishing natural resources. Innovation, he argues—new and improved ways of doing things—provides the answer. Smith et al. are of the same opinion, adding to these two challenges, the need to move from 'debt-driven consumerism'. Peter Fieger and John Rice in their chapter on the relationship between skills, innovation and organisational performance find no clear link between innovation and productivity, noting the lack of consistent effects in the model they used. Part of this might be attributable to limitations with the dataset on which they based their analysis, but could also be suggestive of an indirect and contingent relationship between innovation and performance.

Misko and Nechvoglod argue that firms innovate for a number of reasons, not just to improve the bottom line. From their analysis of firms in three industries—financial services, retail and wholesale services and biotechnology—they propose that innovation in firms is prompted by the availability of new or improved technologies; regulatory change; deficiencies in resources or current workplace practice; economic realities (that is, responding to international and domestic competition, the need to contain costs and to operate efficiently and to increase revenue); and consumer demand. Of particular interest are innovations arising from the necessity to remain compliant with government regulations and industry codes of practice. They use the example of the biotechnology industry: Australian legislation requires drug companies wishing to test and trial new drugs to undergo accreditation and associated ethics approval processes. With accreditation under their belt, Australian drug companies have an immediate entree to domestic and international trials; this is in stark contrast to their international counterparts who have to undergo approval processes before their services are engaged. Similarly, Dalitz, Toner and Turpin in their chapter describe OHS regulations as a driver for innovation in the maintenance of safe work practices in the mining industry.

How is innovation supported and fostered?

Skills for innovation

Just as it is firms that innovate, increasingly it is incumbent on the people in these firms, and their skills, to drive innovation. Skills are of critical importance in innovation but the chapters make clear

that there are no generic innovation skills; in fact Toner's and Dalitz et al.'s chapters explicitly state that there are no innovation skills per se; rather, the skills required depend on the context, and can be considered at various levels. What is clear however is that there is a large variety of skills that can be relevant to innovation.

At one level we can think about skills in terms of where they are required in the innovation process. Toner's chapter discusses the importance of trades and technician occupations (and by extension the skills associated with these occupations) in the research and development workforce. He mentions that these skills become relevant after the initial conception of the innovation (where higher education-based scientific skills are used). In contrast, other chapters, in particular those of Fieger and Rice and Stanwick and Beddie discuss skills for innovation in terms of the output-based ABS definition of innovation, and the ten core skills used in the ABS innovation survey. Fieger and Rice, for example, find a contrast between skills used in new goods and services innovation, which deploys a variety of skills, including trades, scientific and research, marketing, and business management, and organisational process innovation, which uses a broad spectrum of skills, apart from trades and scientific and research. Agarwal and Green argue specifically for management skills, in particular people management skills, as a key driver of more innovative and productive workplaces.

On another level innovation skills vary by industry. Stanwick and Beddie find variation by industry when looking at the differences in skills used by innovation-active and non-active firms. For example, there is a large difference in the proportion using trades skills in the retail trades, whereas in the professional, scientific and technical services industries there is a large difference in the proportion using IT professional skills. Interestingly, there was one similarity across the six industries examined, in that there was a substantial difference in the proportion of innovation-active and non-active firms using marketing skills. Marketing can be seen as a facilitator, an enabler or as an 'innovation skill'. Misko and Nechvoglod also find that marketing, as well as business management, finance, and project management, are important skills in innovation in the retail, wholesale and financial services industries. By contrast, in the biotechnology industry, engineering, scientific and research skills are important. This is an industry where a great deal of R&D also occurs. Dalitz, Toner and Turpin in their chapter generalise skills variations by industry by claiming that rather than finding any generic innovation skills, they found that workers with strong skills and knowledge in their vocation were more effective in innovation.

There is also discussion of other types of skills that, in concert with technical/vocational skills, can be termed generic or cognitive and which appear to be important in innovation. Deitmer mentions that workers and craftsmen need multiple skills, which emerge both from theoretical understandings and practical experience. Rumsey, in discussing how neuroplasticity can be applied to skills in innovative workplaces, lists a variety of cognitive and generic skills that may be required, depending on the situation. Rumsey further mentions dispositional and attitudinal characteristics (for example, showing initiative), which are not skills in themselves, but are precursors to effective learning for skills.

VET system

In the earlier book of readings on innovation, Pickersgill noted that from colonial times the VET sector had a role to play in imparting skills for innovation. Early settlers needed to adapt existing equipment to Australian conditions, so innovation was mainly concerned with extending and modifying existing technologies. People with a technical background were used for this rather than R&D departments. Dawe and Guthrie, in their overview to the book (Dawe 2004), emphasised this notion, using the expression 'continuous improvement', and argued that this is how innovation occurs in industry; they contend that this is where VET has a role. This current volume discusses innovation in a similar manner.

There are three aspects of the VET system that support innovation in industry. Firstly, VET provides training for a broad range of skills relevant to innovation. Deitmer demonstrates, using a

specific case study from Germany, how apprentices can play a vital part in innovation in the firm. More generally, the ABS statistics on innovation indicate the importance of trades-related skills across many industries such as manufacturing (see the chapter by Stanwick and Beddie).

Beyond the trades and technicians, VET has the ability to provide a broad range of skills useful for innovation. Misko and Nechvoglod argue that skills such as finance, marketing and business management can be taught by the VET system but that often employers prefer university graduates in these areas. To this end, Misko and Nechvoglod do provide some suggestions on how VET can engage with industry vis-a-vis these skill areas.

Secondly, and related to the first point, the formal VET system provides the underpinning competencies required for innovation. This was pointed out by Toner, who emphasised the importance of formal VET training for the trades and technical jobs in the R&D workforce, and also by Dalitz, Toner and Turpin, who found that VET should focus on the core skills of the vocation (as well as providing the ability to learn and adapt), which in turn will underpin innovation or equip workers to be innovative. Specific skills (such as using a particular piece of equipment) can be learnt on the job, as can 'top up' skills—keeping up with the latest trends. It is argued in various chapters that VET also has a role in the provision of short course training for workers to obtain new skills. There is nevertheless some criticism of the VET system in Toner's chapter; he perceives that VET does not teach enough underlying theory or knowledge. Dalitz et al. found that the formal education and training system 'was vital in providing the underpinning understanding on which new learning is based'. This means there may be some implications for the way VET programs are put together and taught as well as for the design of training packages in the future, so that underlying theory and knowledge are properly incorporated, as well as the additional skills that may be required for innovation.

The third point is that VET's potential to inject itself into the innovation system could be slipping away. VET should not be seen in isolation but rather as part of a system; that is, VET can work in partnership with other agencies to support innovation in firms. A couple of the chapters provide suggestions on how this might occur. In terms of skills provision in areas such as marketing, finance and business management, Misko and Nechvoglod suggest partnerships with universities and professional societies to deliver courses, and partnerships with vendors for short courses for existing workers. In terms of VET keeping up to date with innovation, Dalitz, Toner and Turpin find that teachers use a wide range of linkages with industry, particularly through industry skills councils, while the personal networks of teachers are also very important.

Government support

Rice discusses national innovation systems involving governmental, scientific and industrial agencies. The aim of government intervention is to improve the contexts in which industries operate. From a different perspective, Rice sees 'creative destruction'—where innovation produces both winners and losers in firms and industries—as a rationale for government intervention to support risk-taking by firms.

Rice and Stanwick and Beddie also discuss more specific roles for government in fostering innovation. Both chapters, as does the concluding note by Karmel, agree that governments have a distinct role in investments in education and training. The Cutler Review of the national innovation system noted that investment in education and training at all levels was essential for the nation's capacity to innovate (Cutler 2008).

Beyond this, the role of governments is more contested. Karmel, for example, notes that not all see the need for a direct role in innovation. Notwithstanding this, even the most avid free marketers point to critical areas for government action. An obvious example emerging is the protection of intellectual property legislation (patents, trademarks etc.); another is anti-trust laws that promote competition and inhibit anti-competitive behaviour.

Thinking about the VET system specifically, Stanwick and Beddie contend that governments can play a role in raising the awareness of the role VET can play in innovation and the innovation system, although as the third point in the previous section implies, this is a two-way street. For example, VET practitioners could be involved in innovation councils, industry skills councils or policy development. In the earlier volume, Guthrie and Dawe (2004) noted that VET was not as involved in the national innovation system as it could be and argued that the VET sector has a lot to contribute in this area.

What can firms and enterprises do to encourage innovation

A number of studies give serious consideration to the impact of managerial practices and workforce organisation on innovation in firms, claiming that successful innovation is largely dependent on ‘organisational characteristics’. Agarwal and Green’s paper, which is based on the results of a large study on management practices and enterprise performance (the study was commissioned as a consequence of the 2009 innovation White Paper), claims that high-performing management is a crucial component in innovative enterprises. Their paper notes that, since Australia supports a high proportion of small and medium firms, it is vital that their innovation effort be improved; this, they argue, means that management and ‘management talent’ play a critical role in driving innovation in enterprises and across the nation. In support of their argument Agarwal and Green cite a recent survey that listed the key impediments to fostering innovation as: ‘short-termism in political and business thinking; under-investment in education and infrastructure; and risk-averse and insurance-driven attitudes’, all of which signal the urgent need for attention to the ‘behaviour and mindset’ of Australian managers. Furthermore, the results of their larger research study indicate that Australian firms need to improve their HR practices to attract and promote the best available talent, while instilling a ‘talent mindset’ amongst their workforce. To test their hypothesis that management practices impact on innovation, the research study matched firms’ management scores against the number of innovation patents issued, with the results indicating that well-managed firms appear to be more innovative—the firms with the highest management scores achieved the highest number of patents.

But what does excellent managerial practice actually mean for organisations in the business of innovating? Stanwick and Beddie tell us that leadership and workplace culture are important factors—as contributors to the 2004 collection also highlighted when they tease out the defining characteristics of an innovation-producing culture as: ‘... dependent on fostering problem-solving, creativity, entrepreneurship, initiative and drive’. Misko and Nechvoglod also flag the central importance of leadership, claiming that without leadership support for innovation it won’t occur. Similarly, Rumsey acknowledges the importance of an encouraging and supportive workplace culture, one that recognises that everyone has the potential to contribute to the organisation’s innovation goals, regardless of age. Rumsey’s chapter examines advances in neuroplasticity and how knowledge of how the brain continues to grow and learn can be put to good service in the deployment of older workers. Toner’s survey of the R&D trades and technician workforce found that work organisation systems play a significant role in their working life, and, ‘arguably in the performance of R&D’, citing as important, ‘variety of work; engagement in problem solving; access to training and learning new skills; exposure to new technology ...’ Other aspects of work organisation believed to contribute to effective R&D (innovation) work identified by the survey include the complementarity of skills across the various categories of workers comprising the R&D team; job security and the various benefits flowing from this; teams working in close proximity, thus facilitating the ready exchange of information and problem-solving; and team members being encouraged to participate in all stages of the R&D process, from concept planning to the development of prototypes.

Deitmer’s chapter on building the innovative capacity of workers discusses a case study which illustrates how learning and working can co-exist in the firm. Deitmer discusses some best practice exemplars such as incorporating real work and learning tasks from the beginning of the

apprenticeship. What is clearly emphasised, however, is the existence of a corporate culture that facilitates cooperation and communication between all the relevant parties involved in the innovation process—in addition to the combination of theoretical and practical learning.

Similarly, Smith et al. in their chapter, which describes an ongoing research project into the development of a model of innovation built on the notion that various human and technological factors affect the capacity of enterprises to innovate, argue that ‘the ability of enterprises to innovate depends on the effective management of human resources ...’ These authors develop a framework in which human and technological capital are those elements of enterprises that stimulate the development of innovation capacity; that is, the potential for innovation within the enterprise, and also known as ‘absorptive capacity’. Smith et al. argue that, in contrast to earlier work which sees a role for human resource management (HRM) in managing innovation, they envisage HRM as a tool for building innovation capacity. To this end these researchers have identified a ‘bundle’ of HRM practices that appear to act as a stimulus to innovate, taking work conducted in Denmark in the mid-1990s as their exemplar. Smith et al. explain that in this study bundling HRM practices encompasses interdisciplinary workgroups, quality circles, employee suggestion schemes, planned job rotation, delegation of responsibility and so on. While Smith et al.’s research into Australian enterprises is ongoing, results so far indicate that a number of stimulus factors appear to be associated with the development of higher levels of innovation capacity and include the use of flexible work practices and the bundling of high performance work practices.

While the workplace setting and its culture is critical in innovation, Dawe and Guthrie in the earlier collection note that successful innovation relies on an ‘ability to harvest ideas and expertise from a wide array of sources’, highlighting the benefit of partnerships to the innovation project. In this context Rice alerts us to an important concept emerging in the innovation literature, that of ‘openness ... as a means to optimise innovation at all of its stages’. Basically, the notion of openness is premised on the understanding that innovation doesn’t occur in isolation, that it relies on alliances and networks and collaborative relationships.

As Misko and Nechvoglod remind us, however, innovation requires resources, for example, substantial infrastructure, the re-organisation of workstations to facilitate some of the HRM practices described above, and state-of-the art technology, all of which can be costly, and, as these authors note, rely on firms having the funds themselves or the ability to access them. Also costly can be maintaining the capacity to keep abreast of developments and changing trends through, for example, participation and attendance in trade fairs and expos.

Having said this, technology is part of the ‘absorptive’ capacity of the firm. Absorptive capacity can be seen as the extent to which innovation stimuli, both technological and human, are able to be absorbed within an enterprise in order to provide the capacity to innovate. Toner also reminds us of an important point raised in other essays (Agarwal & Green; Smith et al.), that the effect of innovation is cumulative (an effect of developing absorptive capacity): the more that innovation occurs, the better and more conducive are conditions for further innovation, a point also made by Tom Karmel in his concluding remarks to this collection. This is a very important point and the chapter by Smith et al. concerns itself with the human side of this equation, highlighting the role of the learning and development system in this. Another implication of developing absorptive capacity in a firm is that it is able to better assimilate new information external to the firm. In this way absorptive capacity (or developing capacity to innovate) should lead to firm success.

Concluding thoughts

The chapters in this book present some challenges for the development of skills for innovation and the role of the vocational education and training system in this. Firstly, the nature of skills development has implications for what may be included in training packages. The chapter by Dalitz et al. suggests that training packages should pay explicit attention to fundamental knowledge

(of a vocation), as this increases the ability of individuals to solve problems and to adapt to different situations.

Another challenge for the sector is keeping abreast with new developments in industry—this is not to say that this does not occur—but it is an ongoing challenge. Meeting this challenge could involve a variety of strategies, including direct engagement with enterprises and engagement with industry skills councils.

Finally, some of the chapters in this book such as that of Misko and Nechvoglod, and Dalitz et al., imply that, when it comes to employing people to be part of innovation teams, there may be a preference by enterprises for higher education graduates in some areas, with both education sectors competing for students in ‘contested’ areas such as marketing, business management, finance and IT. This is a threat to the VET sector, which may well be relegated to offering initial courses that articulate into higher education and the short courses and top-up skills that Toner discusses.

As many of the contributors highlight, skills of all dimensions are crucial to innovation and the innovation capacity of Australian enterprises. With VET’s mandate being the provision of skills, it would be a pity if the sector were ignored in this vital contribution to Australia’s economic prosperity.

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Innovation in the modern economy

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Innovation entails the systematic integration of knowledge creation and commercialisation. As such, innovation integrates the roles of the inventor, the manager and the entrepreneur. Innovation requires a configuration of activities, rather than an individual activity, and further requires contextual institutional support if it is to thrive. Economists have noted that, in aggregate, technological innovation is a strong driver of economic growth—and yet the ‘creative destruction’ of innovation creates winners and losers and hence the impetus (if not perhaps the ‘economically rational’ justification) for government intervention.

Within organisations, innovation is intrinsically related to the effective creation, management and diffusion of knowledge. As industrial knowledge has become more complex across industries, firms have been driven to collaborative mechanisms to share the challenges and risks associated with knowledge development and diffusion.

Introduction

By any measure, academic and policy interest in the field of innovation is growing. The business news is replete with coverage of successful innovation and its impact on the economy and society. Research on innovation in the academic business literature has never been greater; the constitutive determinant and outcome elements of innovation have been dissected and analysed, with findings generally supporting the notion that innovation is a means by which organisations can achieve greater efficiencies, effectiveness and financial and strategic performance.

Systemically, within industries, within nations and within the international economy, innovation improves aggregate performance through the adoption of enhanced operational efficiencies, the introduction of novel products and services to meet emerging wants and needs, and through the introduction of improved marketing regimes. Innovation improves these forms of performance through its processes of diffusion (where firms and other agents learn from best practices developed elsewhere) and through the processes of fundamental knowledge creation.

Among other challenges, the fact that successful innovation can be measured through the observance of a functional and effective procedural system as much as through the observance of an outcome (like a new product or service) makes it very challenging to measure, research and assess. In developing this chapter, we keep this challenge in mind, focusing wherever possible on the contextual elements within organisations and systems that facilitate and/or hinder the development of innovation processes and outcomes.

In an economic sense, the creation and diffusion of innovative technologies and processes have the capacity to increase the factor productivities of both labour and capital, increasing the total factor productivity of firms, industries and economies. The words ‘innovative technologies’ are an abstraction—innovative technologies and processes can be observed in both tangible and intangible forms; for example, as the creation and/or adoption of new processes and procedures within firms, in the form of new capital (plant, equipment, software etc.), and as improved worker skills, among numerous other incarnations.

Technological innovation and economic change

Joseph Schumpeter (1934) and many since (for example, Robert Solow’s 1957 exogenous growth model) have noted that innovation and technological change are essential drivers of economic growth within firms and cumulatively within economic systems. Indeed, from the Industrial Revolution forward, one could scarcely imagine a world without scientific invention preceding the introduction of new products and services.

Changes that are exogenous (externally derived) relative to firms and industries are making innovation both more influential to economic change, on the one hand, and more prevalent within firms, industries and economies, on the other. Increased globalisation and industrial diversification are creating the atmosphere for more complex product and service value chains, where firms collaborate in the development of increasingly complex product and service offerings. These heightened interdependencies between firms are increasing the opportunities for more specialisation by firms, and for new innovations in products and services.

An example of such trends has been the convergence of the telecommunications, information technology and media sectors in the form of new multimedia devices such as Apple’s i-Pad and i-Phone. These devices allow users to interoperate with one another and with the information available from media companies. Importantly, Apple products were based on important advances in mobile telecommunications and digital media technologies that were developed outside its own boundaries. It has built a very successful business model by integrating and re-combining these technologies and by building links with the music, entertainment and telecommunications sectors to create a strong, defensible business strategy.

The evidence on the positive outcomes from innovation in terms of the sponsoring firm is, however, far from conclusive. The longitudinal and interlinked processes that form successful innovation (from investment in invention, through to research and development, and finally to commercialisation) all entail risky choices for firms and managers. At each stage of the developmental life cycle, the competitive vagaries of industries and consumers may work against the sponsoring firm, rendering their investments worthless and potentially destroying value that was embedded in foregone products, services and capabilities.

For industries where innovation is occurring, there is evidence that it tends to coincide with perturbation and uncertainty—both of which make planning more difficult. Innovation introduces Schumpeterian ‘creative destruction’ into industries and economies. The reinvention of goods and services and the renewal of value-adding processes through the introduction of new ways of doing business create winners and losers. While the economy as a whole may benefit from new, innovative and more efficiently produced products and services, at the firm level the gains of the emerging leaders come at the expense of the laggards who fail to pre-empt technological and market change.

Why does innovation matter?

The world economy over the last two decades has been transformed by two related phenomena. Firstly, there has been a long, and generally sustained, period of economic growth. Notwithstanding the economic ructions and uncertainties driven by the Global Financial Crisis, the World Bank suggests that world GDP has maintained an increase averaging over 2% per annum for two decades. This economic growth has been both a cause and an effect of major changes in societies, especially in Asia. China, for example, has experienced rapid industrialisation and an emergence of an economically and socially influential middle class. Much of China's wealth has flowed from the growth of a prosperous manufacturing sector that developed (at least initially) from the inward transfer of manufacturing technologies and innovation developed in Western nations (Chen 2009).

Secondly, an understanding has emerged that there is a limit to an economic growth paradigm that relies on the consumption of finite resources in an unsustainable manner. Sustainability is at the top of the agenda—for individuals, firms and nations. While the world is grappling with the environmental consequences of decades of unbridled combustion of carbon-based fuels, in fact it may be the scarcity of these fuels that brings reductions in CO₂ production before policy initiatives and markets do. In either case, limits to unsustainable growth are becoming evident, and maintaining economic growth, and all of its concomitant social benefits, will rely on the creation and diffusion of new and improved ways of doing things—namely, innovation.

Together, these two paradigmatic changes are transforming societies and industries. National governments are increasingly interested in productivity and efficiency as means to maintain economic growth within an era of higher commodity prices and concerns about waste and sustainability. The diffusion of innovation provides opportunities for both individual firms and for economic systems to ensure that they operate at the efficient technology frontiers of the operational systems they utilise. The creation of new technology allows for this technology frontier to migrate outwards, that frontier serving to improve the efficiency of their industries.

Clearly such a stylised conceptualisation of innovation diffusion and creation assumes away many problems and frictions. Primary among these assumptions is the costless diffusion of best practice amongst industry participants. In reality, innovation within an industry creates winners and losers (cf Schumpeterian creative destruction). The winners are often the firms with the lowest stocks of immutable resources, and the losers hence are often characterised by large asset stocks of tangible and intangible resources, often plant and equipment and extensive expertise and skills developed over long periods in areas that are no longer relevant in the emerging industrial landscape.

Examples of this asset stock value decay (Dierickx & Cool 1989) can be observed in the photographic industry. The emergence of digital photography as a replacement for colour film created dire outcomes for firms like Eastman Kodak, which had led the industry under the prior technology (its Kodachrome film was an industry leader). Kodak has struggled to compete successfully with companies leading in digital photographic technologies. In essence, the benefits to emerge from innovation do not come without costs, and these costs tend to be concentrated and borne by non-leaders, rather than spread across an industry.

Less commonly, exogenous changes may deliver windfall gains to firms 'at the right place, at the right time'. This occurs as elements of their stock of technology and competencies are positively re-valued by technological and/or environmental change, or contextual complementary innovation they may not have initiated. An example may be a re-rating of the value of solar electricity generation technologies due to the emergence of concerns relating to climate change and carbon dioxide abatement.

Leading firms in high-technology industries are increasingly characterised by high ratios of R&D to turnover and ever-diminishing product-development cycles. For these leading firms, competitive advantage is seen to be determined by their unique constellations of immobile (or at least 'sticky')

and heterogeneous resources, the quality and scope of research capabilities, and technical skills of a high order. These leading firms, which generally confront highly uncertain and turbulent product and factor markets, benefit from strong links between industry and science. Governments direct their assistance to improving the flow of knowledge within their national innovation systems by nurturing networking, cluster development, the promotion of collaborative learning, and the facilitation of user–producer interactions.

Hence, the processes of innovation and the successful creation, development and dissemination of knowledge are intrinsically linked (Jensen et al. 2007; Kogut & Zander 1993). Knowledge can (generally) be considered a non-rival good—something that, once created, can be used by multiple agents without any risk of depletion. Indeed, much of the literature on the network economics of standards-based industries points to positive externalities, as multiple users adopt knowledge (Agarwal, Audretsch & Sarkar 2008). This attribute of knowledge has created a strong nexus between knowledge, innovation and networks—a nexus explored more fully later in this chapter.

What drives innovation?

Innovation is created by entrepreneurs and firms creating new knowledge, and combining existing knowledge in new ways. It is sustained by two main drivers: one driver is contextual and external to the firm; the other is embodied in the firm and its operational and knowledge system. Innovation is driven by knowledge creation and diffusion, and hence there are spatial and relational aspects to the sustenance and development of innovation—both within firms, and also within regions and nations.

National innovation systems

Firstly, regions and nations support ‘innovation systems’. The innovation systems approach is an essentially institutional notion that focuses on the nature of the linkages between governmental, scientific and industrial agencies, on the one hand, and the quality of relevant system-wide (generally national) stocks of technological competencies and capabilities, on the other (Chang 1994; Freeman 1995; Lundvall 1998; DiMaggio 1998). National innovation system (NIS) research can thus be thought of as a special form of neo-institutionalism, which suggests that variance between institutional effectiveness leads to variance in economic outcomes (North 1991).

Much of the literature on national innovation systems espouses proactive and strategic industry policy intervention by governments (Lundvall 2007). In policy terms, such interventions aim to improve the regional and national context within which firms and industries are embedded (Laranja, Uyarra & Flanagan 2008).

The policy dialogue on innovation generally contains three prescriptions. Firstly, governments should facilitate knowledge creation and transfer and remove unnecessary impediments to its diffusion. Secondly, governments should subsidise the creation of new knowledge through publicly funded scientific research and support for higher education. This is often considered a strategic investment if it builds on immovable resource endowments in host countries, ensuring local economic development if successful. Thirdly, and somewhat related to the second point, investments in human capital (through better education, especially at the higher [university] level, although also in vocational areas) are seen as vital.

Somewhat problematically, this places governments in the role of selector of industries for support. Pack and Saggi (1996) note that even in Asia, host to the most notable examples of managed industrial emergence (Japan and South Korea), a number of sub-optimal historical examples exist of policy failures and related inefficient industries.

When all goes to plan, innovation creates leading firms and hence impacts on national economic competitiveness. Chang (1994) attributes much of the success of the South Korean economy, post

the Korean War, to the success of its national innovation system, and the key coordinating role played by government. Indeed, many national success stories have been similarly deconstructed down to their institutional determinants—from Norway’s curious national economic mix of hydrocarbons, fishing and marine transport (Fagerberg, Mowery & Verspagen 2009) to the US’s military-industrial complex (Mowery 2009), with its concomitant knowledge spillovers. Thus even the United States, with its general commitment to unfettered capitalism, has run a quasi-interventionist industry policy through its institutional support for high-technology and defence-related industries (Pack & Saggi 2006).

There is now such a preponderance of evidence, that policy interventions and public investment in national scientific and research institutions do matter, that support for national interventions in innovation development is very much received wisdom and rarely subject to debate. Even free market purists acknowledge that market distortions caused by interventions elsewhere in the world economy creates a ‘special case’ for intervention to rebalance market power.

Other justifications for government intervention to support national innovation systems have also been proposed. One of these relates to the presence of dynamic scale economies, whereby firms and industries accumulate expertise and capabilities in a non-linear, path dependent manner. For firms within ‘infant industries’, which are often nascent and emergent in nature, the absence of government support and/or protection may make it impossible for the initial growth phase to be secured (Melitz 2005).

Another key justification to interventionist actions relates to coordination failures, which are especially relevant in emerging industries. Coordination failures can be thought of as a special case of the ‘tragedy of the commons’, where individual actors, behaving in their perceived self-interest, may cause aggregate problems. Nascent industries require simultaneous or consecutive investments to achieve viability (Pack & Westphal 1986; Pack & Saggi 2006).

The political economy of national innovation system interventions

As has been discussed, innovation and technological change has been shown to be a fundamental driver of economic growth. The positive (aggregate) economic outcomes associated with the creation and diffusion of innovation, however, create frictions in markets as laggards lose market share to innovative, entrepreneurial firms. This friction creates very real and highly concentrated economic and social consequences among laggard firms, sectors and regions.

This differential impact of innovation, and more particularly the policy context of innovation, makes it a somewhat contested ideological terrain. Governments are thus increasingly interested in issues relating to innovation. Policy pronouncements regarding the importance of innovation in economic growth are commonplace, and Australia recently completed a major review of its national innovation system (Cutler 2008). Policies that aim to increase technological innovation in declining sectors of advanced economies are seen, while not a panacea for these declines in industrial capacity in developed nations, at least as a means of easing the burdens of economic transition and reinvestment.

In an era of globalised markets and (relatively) free trade, there is a natural tendency for production to migrate to its location of highest comparative advantage—often driven primarily by low labour costs. In effect, this has meant a massive transfer (loss) of developed nations’ manufacturing capacity to Asia, with concomitant, and heavily concentrated, losses of employment and capital value in developed nations’ economies. Representative democracy in Europe, the United States and Australia has created a voice, hitherto relatively unheeded, for greater trade protectionism to militate against these negative consequences.

Somewhat ironically, given the massive trade surpluses accrued by the Chinese economy and its manufacturing sector, China’s factories are replete with manufacturing technologies and equipment

that have been developed in the United States and Europe (Guan et al. 2006). This inward transfer of innovative technology to Asia is an example of technology diffusion, and also a driver of the (Schumpeterian) creative destruction of the national manufacturing industries for which this manufacturing technology was initially developed to serve.

In terms of the creation of sustainable competitive advantage by firms, innovation should allow firms to achieve effective differentiation in markets (Ireland & Webb 2007). This, however, tends to be short-lived, as few firms manage to continuously innovate and maintain effective differentiation in the absence of strong barriers to entry and replication (for example, patents and other forms of intellectual property protection) (Crook et al. 2008). As such, innovation introduces competitive cyclicalities into firm and industry life cycles, creating investment uncertainties and often problematic consequences for firms, investors and economies.

There is also an acknowledgment of the importance of innovation for the achievement of non-pecuniary outcomes—social fairness, community health and ecological sustainability (Pitelis 2007). In these areas, innovation is seen to have positive, direct and also secondary effects—direct effects in terms of reducing waste and spreading best practices, and indirect effects in terms of increasing the ‘common wealth’ of industries, communities and nations.

These benefits (like ‘beauty’) are somewhat ‘in the eye of the beholder’. For example, innovations in medical technology, while extending the technological frontier of what is medically possible, is also driving a steady increase in the cost of medical care. Where the consumption of high-technology, high-cost care is partially subsidised (as is the case in Australia), such care may increase both government expenditures on health, while also pricing out sections of the community who are unable to afford private health cover.

In summary, the costs and benefits of innovation may be considered complex, dispersed and heterogeneous. Individuals do not live as aggregates, and society must balance the dispersed benefits from improved technological change and the inevitably concentrated costs.

Organisational drivers of innovation

Secondly, the success of innovation is heavily determined by organisational characteristics. Cohen and Levinthal (1990) have noted that some firms are innately better at generating and/or absorbing new technology and innovations than others. The cultivation and effective transformation of knowledge into products and services by firms is also a source of innovativeness and has been shown to be very heterogeneous between organisations, even within the same industry (Coombs & Hull 1998; Grant 1996; Greve 2005; Kogut & Zander 1993).

Asian, and most especially Japanese, firms have been shown to place a high value on the development of collective knowledge resources (Nonaka 1994; Nonaka & Takeuchi 1995). These authors show that Japanese firms in high-technology industries place a great emphasis on the management of both the tacit and explicit sides of knowledge in the facilitation of innovation.

For this chapter innovation is understood as a multifaceted and interlinked process. Innovations are often thought of in terms of evident changes in the marketed goods or services of firms, but the presence or absence of this ‘last stage’ of innovation (which is often the only measure or indicator that we have) tells us little about innovation’s relative financial and strategic importance for the innovating organisation. The academic literature and most associated practitioner commentary on innovation have suffered greatly from a lack of precision relating to how the innovativeness of firms is assessed.

Innovation should be thought of as a ‘chain-link’ of successful activities (Kline & Rosenberg 1986), of which product or service changes are the most evidently observable aspect. Roper, Du and Love (2008, p.962) note that the ‘innovation value chain’ is a ‘recursive process through which firms source the knowledge they need to undertake innovation, transform this knowledge into new

products and processes, and then exploit their innovations to generate added value'. Indeed, innovation in such a conceptualisation can be viewed as an iterative process, concurrently integrating basic research and invention, improved operational and organisational processes and improved methods of marketing (Liao & Rice 2010).

Innovation and inter-organisational networks—the benefits of openness

Few would disagree with the contention that it is basic research and development—fundamental knowledge creation—that provides the kernel from which innovation emerges. Such knowledge creation is generally (although not exclusively) inspired by good science. This research occurs in universities, in government and private research agencies, in privately and publicly owned organisations and in the minds of creative inventors. Increasingly, it occurs within networks of these agencies and individuals, facilitated by new technologies that have reduced the transaction and coordination costs associated with communication, knowledge exchange and inter-organisational alliances.

An important emerging literature in the innovation field relates to the importance of 'openness' (Chesbrough 2003) as a means to optimise innovation at all of its stages—knowledge creation, product/service development and commercialisation. This literature was inspired by the observation that innovation is rarely achieved within the confines of a single organisation and that the leading organisations in almost every industry—from Apple, to BHP, to Xerox—create portfolios of alliances (Lavie 2009) that facilitate their innovation processes. It was a counterpoint to the 'closed innovation' notion, which emphasised the development of innovation wholly within the contractual boundaries of individual firms.

This approach, which focuses on alliances and inter-organisational networks as everyday business practices that facilitate successful organisational operations, was seen as necessary due to the rapid increase of technological complexity in all industries, and most especially industries that employ information technology as a core area of expertise. At a time of increasingly complex information and productive technologies, higher levels of uncertainty and risk associated with R&D and shorter innovation cycles, it has been suggested that open innovation may be an effective way to deal with these challenges (Arora, Fosfuri & Gambardella 2001; Chesbrough 2003; Miotti & Sachwald 2003).

Interest in these collaborative relationships, including strategic alliances, interfirm and interpersonal networks, has been longstanding—although it increased in the 1980s (Borys & Jemison 1989; Badaracco 1991)—and did not emerge specifically from the innovation literature, but it certainly influenced the field. The term 'open innovation' subsequently entered the innovation lexicon in the early 2000s through a series of managerial publications that expounded the value of utilising R&D collaboration, licensing deals and acquiring patents from other organisations (Linder, Jarvenpaa & Davenport 2003; Rigby & Zook 2002).

Chesbrough (2003) then took such ideas further to present open innovation as a new model on how firms innovate and commercialise subsequent technologies. Open innovation not only recognises the value of ideas that emerge both within and outside the organisation, but it also 'places external ideas and external paths to market on the same level of importance as that reserved for internal ideas and paths to market during the Closed Innovation era' (Chesbrough 2003, p.43).

Highlighting the advantages of open innovation principles, some 'innovative firms now spend little on R&D and yet they are able to successfully innovate by drawing in knowledge and expertise from a wide range of external sources' (Laursen & Salter 2006, p.132). However, to do this, Chesbrough (2003) specifically suggests that the boundaries of the firm must be viewed as porous and that firms should concentrate much of their search activity externally, since firms that are too internally focused will miss out on a number of opportunities.

Open innovation, however, has some limitations. Some potential downsides exist to those firms following an open innovation style strategy. Laursen and Salter (2006), for example, emphasised the

cumulative search costs involved with over-openness compared with ideas developed elsewhere, which may tend to ‘crowd out’ important internal development activities. Furthermore, there are potential trade-offs regarding openness and the need to control key elements of firms’ intellectual property and proprietary resources and capabilities (Chesbrough, Vanhaverbeke & West 2006). In essence, it can be determined that, while openness can stimulate innovation, it cannot be the basis of sustainable competitive advantage if an organisation’s innovation activities are based wholly on ideas sourced from others (Helfat 2006).

Conclusions

The interlinked processes of innovation introduce novelty into the market for goods and services and hence economic perturbation (for better and worse) into industrial sectors, regions and nations. Technological innovation extends what is possible (through an extension of technological frontiers), but for laggard firms, industries and nations, technological change at the frontier is associated only with a greater distance to best practice. The Schumpeterian processes of creative destruction that innovation creates can wreak havoc on laggard firms and industries, and governments see this as a justification for strategic investments to get the institutional context right.

Innovation also leads to structural changes within national and international economies. The long-term growth of technology-based industries and the services sector has made these industries prime targets for government interventions. While this has been the case, there is little robust evidence that the exemplars of success in these industries, nor indeed the wider population of entrepreneurial firms, have benefited significantly from the direct and indirect forms of governmental assistance.

Governments seek to enhance the positive outcomes of innovation through deliberate policy interventions that create a supportive context for innovation, although these investments come at a cost to public finances and often create sub-optimal and inefficient firms and industries. When researchers speak of national innovation systems, attention and emphasis are directed most often to the success stories (the US’s high-technology information technology and communications sectors; Japan’s motor vehicle and consumer electronics sectors; and Germany’s manufacturing sectors) and rather less often to the marginal and occasionally spectacular failures of industry policy interventions to support innovation.

While institutions clearly matter for innovation, and the absence of effective contextual support can indeed prevent innovative firms and industries from emerging, innovation is driven primarily by entrepreneurs creating and organising knowledge and other resources in new and marketable ways.

In this chapter we emphasised the fundamental role of knowledge creation, development and dissemination in the processes of innovation. We then discussed the merits and problematic assumptions of ‘open innovation’—an approach that emphasises the use of inter-organisational arrangements to facilitate and animate into action each link of the innovation ‘chain’. We noted that many ‘macro’ trends—from the steady increase in complexity of products and services, to the emergence of global markets for goods, services and capital, to technological change that reduces transaction and communication costs—are all increasing the need for firms and industries to think more about the benefits from networking, and less about the notional benefits of highly proprietary approaches to knowledge hoarding.

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What skills are relevant to innovation?

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In this chapter we explore what is meant by innovation, skills for innovation and the implications of this for training and government. It is argued that innovation is now a broad phenomenon and has moved far beyond focusing only on research and development. It is also argued that there is no single ‘innovation skill’ but rather there are a variety of skills that are required to foster innovation. Further, these skills and the mix of skills vary by the type of enterprise they are used in. They are not necessarily those traditionally associated with innovation. This all has implications for training and the role government can play in fostering innovation.

Introduction

Human capital is the essence of innovation¹

At the end of May 2010, the Organisation for Economic Co-operation and Development presented an innovation strategy to its Ministerial Council which was built around five priorities for government action. The priorities are intended to underpin a strategic and broad-based approach to promoting innovation for the twenty-first century. Those five priorities are:

- ✧ empowering people to innovate
- ✧ unleashing innovation in firms
- ✧ creating and applying knowledge
- ✧ applying innovation to address global and social challenges
- ✧ improving the governance and measurement of policies for innovation.

Under the first priority the strategy asserts that innovation requires a wide variety of skills, as well as the capacity to learn, adapt or retrain, particularly following the introduction of radically new products and processes. It discusses both formal education as well as ongoing skills acquisition. In relation to vocational education and training, the strategy identifies VET’s role in innovation as helping firms to make incremental changes to production processes and adopt technologies, as well as lifting their overall capacity to innovate.

¹ OECD 2010, *Innovation strategy: getting a head start on tomorrow*, viewed 25 October 2010, <http://www.oecd.org/document/15/0,3343,en_2649_34273_45154895_1_1_1_1,00.html>, p.11.

What is this thing called innovation?

Before we can discuss what skills are necessary for innovation we need to be clear about what we mean by innovation. Innovation is somewhat of an amorphous concept that means different things to different people. To some, innovation is akin to invention, but clearly there is more to it than that. Earlier definitions of innovation centred on research and development activities (or as the ABS frame it, an input-based approach to innovation) and this is still very relevant; however, it does not present the whole picture. What we mean by this is that public policy is interested in economic prosperity, which means improving the productivity of the nation, and this involves a broad range of innovative activities. As Toner (2009, p.6) puts it:

Whilst it is undoubtedly the case that leading edge scientific and engineering endeavours are a crucial stimulus to productivity and economic growth, over several decades the innovation studies literature has revealed that the broader non-HRST² workforce and the non-science and engineering part of the HRST workforce also play an essential role in the innovation process.

The OECD (2010) also highlights that spending on intangible assets (such as trademarks or patents) contributes to output growth. These intangible assets can be a significant contributor to what is known as multi-factor productivity growth—growth in output not attributed to growth in labour or capital inputs. The relevance of this is that this contribution to growth can in part be explained by things such as management practices, organisational process and improved production techniques.

At the firm level we need to think about why firms innovate. One assumption might be that firms innovate to contribute to the bottom line, as manifested by productivity growth. However, other chapters in this book indicate that regulation may also be a driver for innovation. The chapter by Dalitz, Toner and Turpin explains that maintenance of safe work practices is a driver of innovation in the mining sector, and Misko and Nechvoglod find that in the financial services, retail and wholesale, and the biotechnology sectors various types of regulatory compliance are triggers for innovation. So if we think about innovation in these terms, then we arrive at a much broader definition of innovation, one which the ABS refers to as an output-based approach to innovation. More specifically, the ABS (2009) defines innovation as:

The introduction or implementation of a new or significantly improved good or service; operational processes; organisational managerial processes or marketing method.

It is also important to keep in mind that, for something to be an innovation it must be new, or significantly improved, to the firm. The good, service or process may be developed by the firm or be adopted. Elaborating on this definition further, we see that the innovation need not be physical; it can be a process or a practice; that is, it can be an intangible, which as we saw earlier contributes to multi-factor productivity growth.

Of course the broadened definition also makes sense when we see the decline of the manufacturing industry and the increasing importance of service industries in the Australian economy. From Stanwick and Loveder (2010, table 1) we see that in 2007–08 manufacturing accounted for 13% of industry value-added (and declining), while the service industries combined accounted for over 50% of industry value-added in the table.

The data from Stanwick and Loveder further suggest that the type of innovation undertaken varies by type of industry. They examined this in terms of industries that make the largest contribution to innovation. To calculate this they used a rather simple measure—multiplying the percentage of innovating businesses in an industry by the industry's relative value-added to the economy. They then arrived at the six industries with the largest contribution to innovation, which, in order, were: manufacturing; professional, scientific and technical services; finance and insurance; wholesale

² Human resources for science and technology.

trade; mining; and retail trade. Table 1 shows the proportion of firms that are innovating businesses by the various types of innovation for these six industries.

Table 1 Proportion of innovating businesses by industry sector by type of innovation, 2007–08

Industry	Goods	Services	Operational processes	Org./ managerial processes	Marketing methods
Manufacturing	20.6	9.0	28.7	20.8	17.7
Professional, scientific and tech. services	5.6	20.3	21.9	26.2	17.9
Financial and insurance services	2.5	15.5	20.5	24.9	17.9
Wholesale trade	29.8	8.5	22.5	18.0	24.8
Mining	5.4	8.6	22.5	26.1	7.4
Retail trade	30.3	10.8	17.2	19.3	19.8

Source: ABS (2009).

We see from the table that in manufacturing the most common type of innovation reported is improved operational processes, followed by either goods or services innovation. In financial and insurance services, on the other hand, improved organisational and managerial processes is the most commonly reported type of innovation, with goods or services innovation being the least commonly reported within this industry. This also highlights the point made earlier about the broadened definition of innovation and the importance of the service industries to the economy.

The main point we take out of this is that there is a broad range of innovative activity that takes place in firms, not only leading-edge scientific and engineering endeavours, as Toner puts it. Of course the broader definition means that more firms will be reporting innovative activity than was the case in the past, but this is not problematic, as the issue is about new things that can be introduced into a firm that contribute to productivity growth.

At this point it is worth introducing a note of caution—there is not a clear linear relationship between innovation and productivity. In the chapter by Rice and Fieger, which looks empirically at the links between innovation and productivity, and innovation and skills, they find that there is no clear link between innovation and productivity. They state that the ‘evidence on the positive outcomes from innovation in terms of the sponsoring firms is, however, far from conclusive’ (p.19). However, this does not mean that innovation is not beneficial. In this same chapter Rice and Fieger point out that the economy as a whole benefits from innovation even though there may be variations between individual firms.

What is nevertheless implicit from the discussion is that there are implications for the types of skills required for innovation, which is what we are really interested in. Toner (2009) indicates that this whole area is somewhat murky: while there is an implicit recognition of the importance of skills in the innovation process, detail is thin. He states:

Whilst a minimum level of workforce skills have been recognised in the innovation studies literature as a necessary condition for continuous product and process improvement, the specific types and qualities of such skills embedded in specific occupations and industries have not been a central concern of this literature (p.9).

We will examine what is meant by skills for innovation in the context of the ABS surveys on innovation.

What do we mean by skills for innovation?

We can argue that innovation skills per se do not exist; rather, there are skills for innovation that are essentially technical and generic skills and which can drive innovation; these are often cognitive

or soft skills. We can look at an example of a unit from a training package to demonstrate what we mean. The Certificate III in Metalliferous Mining Operations (Open Cut) contains an elective from the Business Services Training Package titled *support innovation and change*. When we look at the skills the unit intends to impart, we see literacy skills, proofreading and editing, ability to accept positive and negative feedback, planning skills to organise work priorities and arrangements, teamwork skills and consultation skills. There is no mention of innovation skills as such or even scientific or engineering skills (which we associate with research and development).

It would seem rather that skills for innovation are broad and there probably needs to be a mix of various skills, depending on the context, for innovation to be successful. For instance, Pro Inno Europe (2007) categorised four different kinds of skills for innovation. These are cognitive (thinking) skills, behavioural skills (for example, problem-solving), functional skills (including basic skills such as writing and numeracy) and technical skills. However, these skills are clearly not mutually exclusive. One could quite easily envisage a situation where thinking, problem-solving, writing and technical ability are required for an innovation. Toner (2009) also mentions that workers in different occupations are increasingly required to obtain a range of generic skills in addition to specific technical skills, arguably in response to ICT technologies that require a common set of skills. Importantly to innovation, more efficient ways of organising work, such as lean production methods—both in manufacturing and service industries—are argued to require a broader range of skills.

Let us explore this notion of a mix of broad skills for innovation a bit further. The ABS, as part of its Business Characteristics Survey ‘operationalises’ the skills used for innovation by surveying ten specific skills, ranging from technical skills, such as engineering and trades, to less technical skills, such as marketing and business management. From the survey we can compare the skills used by innovation-active businesses³ with those of non-innovation-active businesses. Table 2 shows the proportion of innovation-active and non-active firms that use each of the ten core skills surveyed by the ABS.

Table 2 Skills used by innovator status, 2007–08 (%)

Core skills	Innovation-active businesses	Non-innovation-active businesses	Difference
Engineering	13.9	9.2	4.7
Scientific and research	7.2	2.7	4.5
IT professionals	25.0	9.2	15.8
IT support technicians	28.4	11.4	17.0
Trades	29.2	24.1	5.1
Transport, plant and machine. op.	16.9	11.8	5.1
Marketing	33.0	8.7	24.3
Project management	14.9	6.8	8.1
Business management	26.5	12.5	14.0
Finance-related	34.3	17.1	17.2

Source: ABS (2009).

The single largest difference between innovation-active and non-active businesses is in marketing skills—33% of innovation-active firms reported using marketing skills, whereas only 8.7% of non-innovation-active businesses did so, a difference of 24.3 percentage points. There were also substantial differences between innovation-active and non-active businesses in finance-related skills, IT skills (professionals and support technicians) and business management. The smallest

³ By innovation-active we mean businesses which had undertaken any innovative activity during the reference period, including introduction or implementation of any type of innovation and/or businesses, with work on the development or introduction either still in progress or abandoned (ABS 2009).

differences were in scientific and research, engineering, trades and transport-related skills. This is interesting because it seems to suggest that the less technical skills are important in the innovation process, which is consistent with what was said above.

The chapter by Misko and Nechvoglod also points to the importance of these skills in three industries under investigation: retail, wholesale, and finance and insurance. However, let us not be dismissive of the role of technical skills—they are clearly vital in an R&D sense and are commonly used in innovation-active businesses, particularly trades and IT skills. Indeed, the ABS innovation data (see table 3) indicate that trade skills deficits is by far the largest point of skills deficit for innovation-active businesses and also the biggest point of difference between innovation-active and non-active businesses (followed by finance-related and marketing skills). Misko and Nechvoglod in their case study on biotechnology found that scientific and research skills were very important (in addition to project management, business management and finance-related skills).

Table 3 Skills shortages or deficits by innovator status, 2007–08 (%)

Core skills	Innovation-active businesses	Non-innovation-active businesses	Difference
Engineering	3.6	1.6	2.0
Scientific and research	1.7	0.2	1.5
IT professionals	3.8	0.3	3.5
IT support technicians	3.7	0.5	3.2
Trades	13.3	9.0	4.3
Transport, plant and machine. op.	2.6	1.6	1.0
Marketing	5.8	1.6	4.2
Project management	2.4	0.5	1.9
Business management	4.9	2.1	2.8
Finance-related	6.6	2.4	4.2

Source: ABS (2009).

We can examine these variations in industry a little more closely for the six industries deemed by Stanwick and Loveder (2010) as making a high contribution to innovation in Australia's economy; namely, manufacturing; professional, scientific and technical services; finance and insurance; wholesale trade; mining; and retail trade. Table 4 shows for these six industries the proportion of firms reporting that they use a particular skill. The italicised numbers represent the top three core skills used per industry.

While industry context is important, some patterns are discernible in the table. In particular, of the 18 bolded numbers, 11 are what could be termed euphemistically softer skills (the last four categories in the table). Indeed, finance-related skills are in the top three skills for each industry. By contrast, scientific and research skills are not italicised for any industry—including professional, scientific and technical services (perhaps, surprisingly, the second least used skill for this industry). Engineering skills rate highly for the two industries it might be expected these skills would be important in, namely, manufacturing and mining. Trade-related skills also rate highly in manufacturing, as would be expected.

This table also demonstrates that different skills are used more or less depending on the industry. A good example is transport, plant and machinery operation skills. These are virtually not used at all in the finance and insurance industry, but are prominent in mining and manufacturing.

Table 4 Skills used by innovation-active business for selected industries, 2007–08 (%)

Core skills	Manufac.	Prof., sci. and tech. services	Finance and insurance	Wholesale trade	Mining	Retail trade
Engineering	39.3	19.9	*	17.1	42.6	3.5
Scientific and research	13.4	11.0	2.8	6.0	23.0	5.2
IT professionals	20.3	48.4	45.0	25.9	19.9	18.9
IT support technicians	26.2	43.5	35.6	22.9	26.9	24.9
Trades	45.6	12.0	9.4	23.8	34.0	24.5
Transport, plant and machine. op.	34.4	8.7	1.4	23.9	44.5	11.7
Marketing	33.1	32.4	50.1	52.4	25.2	42.3
Project management	15.6	30.3	22.3	10.4	40.6	3.2
Business management	30.2	32.7	49.0	35.0	41.2	21.9
Finance-related	37.5	44.3	63.9	37.5	47.6	27.9

Note: * This information was not available from the survey.

Source: ABS (2009).

It is also instructive to look at the difference in the skills used between innovation-active and non-active businesses for these six industry areas.

Table 5 Difference in skills used by innovation-active and non-active business for selected industries, 2007–08 (%)

Core skills	Manufac.	Prof., sci. and tech. services	Finance and insurance	Wholesale trade	Mining	Retail trade
Engineering	15.0	0.0	0.0	9.7	12.1	1.8
Scientific and research	12.0	4.8	*	1.2	-6.2	5.2
IT professionals	12.5	24.4	31.8	14.5	4.2	15.3
IT support technicians	14.8	22.0	20.0	10.9	9.4	17.6
Trades	1.4	4.0	*	2.4	8.6	18.2
Transport, plant and machine. op.	14.3	5.0	1.4	4.5	12.7	9.7
Marketing	20.9	21.7	35.8	33.9	15.2	31.1
Project management	9.3	14.1	15.1	3.0	15.2	0.8
Business management	16.5	10.3	28.7	18.7	12.6	11.7
Finance-related	18.5	9.7	12.7	17.5	8.7	10.2

Note: * This information was not available from the survey.

Source: ABS (2009).

Interestingly, the largest differences tend to be in the softer skills, particularly marketing (as we saw earlier). Engineering and scientific and research skills do not feature as much, and within mining it appears that innovation-non-active firms use scientific and research skills to a greater extent than innovation-active firms. Once again this does not belie the importance of technical and scientific and research skills, but rather underlines that there is a broad range of other non-technical skills considered important in innovation.

What does this all mean for training?

There are some clear points arising from the discussion above. Foremost, it is clear from what has been said that innovation involves a broad range of skills across a broad range of occupations. Toner (2009) notes that a central message in the literature is that much of innovation is incremental. As such, it involves changes to organisational structures and processes as well as the introduction of new products and services. Hence there are substantial roles for occupational

groups such as trades and technicians, and also financial management, marketing and business management. In particular, the discussion above highlighted the importance of non-technical skills such as marketing, finance and business management in facilitating innovation. There is a role for VET in the imparting of soft skills, although this is a contested area with universities. However, it can be argued that these are practical courses that do not need to be taught in an academic/research environment and that the VET sector is well placed to serve these areas. The challenge for the sector is to convince employers of this.

Misko and Nechvoglod discuss in their chapter that employers often prefer university-trained graduates over VET-trained graduates. An earlier study that examined the importance of higher-level VET qualifications in the training market found that in areas such as multimedia, design, engineering and electrotechnology employers prefer higher education graduates over VET graduates (Foster et al. 2007).

In addition to teaching softer skills, VET is of course well placed to teach the trades and related skills that are important to innovation. Indeed Cutler made the point in the review of the national innovation system that:

The role of crafts and trades in innovation has been massively neglected, particularly in the important areas of continuing incremental innovation in the workplace. (Cutler 2008, p.48)

What we see is a whole range of skills relevant to innovation that the VET sector is well positioned to deliver. Dalitz, Toner and Turpin find from their work that in terms of innovation the training system should focus on teaching the core skills of the vocation. They examined in detail three industry sectors—mining (with an emphasis on mine operations), solar energy, and computer gaming—all of which were seen to have different training requirements.

In the mining industry there is a close connection between how the mines are run, how innovation occurs and how training takes place. Dalitz, Toner and Turpin find that the main source of innovation on a mine site is new equipment that enables more efficient extraction of materials. Given the long lead time required to introduce a new piece of equipment, the engineers involved are able to package new and changed operations so that they are easily picked up by the operators. Training is generally conducted on site by private providers or internal trainers. Because of mine remoteness, the expense of equipment and commercial secrecy, public TAFE (technical and further education) is not used for this type of training

The solar energy industry offers a contrast to mining in that innovation is based on incremental improvements. The focus is on core electrotechnology skills with some top-up training. It tends to be the electricians therefore who are the main tradespeople being trained for the industry. Computer games also stand in contrast to mining and solar energy and have different training needs from the other two industry sectors. In this industry, creativity is at the heart of innovation. To remain at the cutting edge firms need to develop their own tools and conduct this development in house so that privacy is maintained. There are two main skills employed in this industry: artistic and programming, with the talent of individuals being crucial in the creation of more attractive products. The nature of this industry means that training tends to be done on the job and within teams.

These three case studies illustrate the different roles that training can play in the development of skills for innovation. Initial VET has a role in developing the core skills of a vocation, while internal or private training has a role in training for new equipment and processes; here there is also a significant role for on-the-job training.

Let us look at the issue of ongoing training a bit further. Much of the available data on training allow for examination of initial and accredited training but are less robust in terms of ongoing training and workplace training. However, ongoing training would seem to be as important as initial training (and then on-the-job training).

In a study on the R&D technicians' workforce Toner et al. (forthcoming) identified, from interviews with mainly tradespeople and technicians, that filling skills and knowledge gaps would improve the work performance of tradespeople and technicians. In the innovation process, technicians play an important role by helping to translate concept into reality. They have expertise in areas such as determining the feasibility of design options, suitability of materials and cost of manufacture. Toner et al. see a role for VET in the provision of short courses to address skill gaps in areas such as technical writing, scientific method and specific technologies (for example, cryogenics). Of course to do this VET needs to keep up with new technologies; however, as Misko (2010) has found, the VET system does have the capacity to respond. If we look at the example of technical writing, Misko identified units of competency in existing training packages that could be the basis of a short course. This is similarly the case for cryogenics.

Further to this there would seem to be a substantial role for informal training or more specifically on-the-job training. Dalitz, Toner and Turpin point this out in their case studies in this book. They found that the skills and competences for innovation were learnt at least partially on the job in all three case studies (mining, solar energy and computer games). If we look at the computer games area, the way the industry is set up almost demands on-the-job learning. Within this industry companies choose which technologies they will use idiosyncratically, meaning that students cannot learn all that they will need through the formal VET system, although of course there is a need for core programming or art-related skills. Much of the training in this industry is internal to the company through mentoring, informal exchanges and a lead person passing on skills they have learnt or developed. Misko and Nechvoglod also found in the industry areas they examined (retail, wholesale, finance and biotechnology) that firms use on-the-job training to develop new employees and existing workers. Ruth and Deitmer (2010) also point out the importance of learning opportunities at work and while working, stating that the better the learning opportunities workplaces provide, the more opportunities there will be to involve employees in the innovation process.

While we have been arguing that there is a role for VET in the development of skills for innovation, there can nevertheless be some not-so-positive implications of innovation. On the downside, Toner (2009) argues that there is not a universal tendency towards an increased demand for skills as a result of innovation. In fact, with innovation embracing systems as well as products, we may expect that some jobs will disappear or become deskilled.

By extension there is not necessarily a need for higher levels of qualifications, or indeed any qualifications. This is despite the current policy environment that encourages the uptake of degrees and diplomas, and forecasts indicating that there will be a dramatic increase in degrees and diplomas in the future. To take an example, Stanwick and Loveder (2010) found that the retail industry, which reports one of the highest levels of innovation (over 50% of firms), had about 60% of the workforce without post-school qualifications. This contrasts somewhat with the professional, scientific and technical services industry, which had about 44% of firms innovating in 2008 and only 21% of the workforce without post-school qualifications. This can be interpreted in a few ways. We could say that qualifications are not important to innovation. This could be partly true, although one is wary about underplaying the role of qualifications, as they provide signals that individuals have undertaken formal education and training and have therefore obtained skills that can feed into innovation.

Another explanation is that innovation involves only certain people in the company. To illustrate this point Toner (2009) calculated a measure of innovation intensity. The measure was calculated by dividing the share of total innovation expenditure by share of total GDP by industry. Innovation intensity was calculated to be highest for the wholesale industry (a ratio of 4.4) and lowest for the retail and accommodation, cafes and restaurants (0.6) industries. Coincidentally, these are the two industries with the highest proportions of the workforce with no non-school qualifications (59.6% and 62.3% respectively) (Stanwick & Loveder 2010).

Let us look at retail a bit more closely. This is the industry reporting the second highest proportion of innovating businesses, yet has the lowest innovation intensity and one of the highest proportions of employees with no post-school qualifications. This would seem to support the argument that only certain people in the organisation are involved in the innovation process—at least in some industry sectors. This would also suggest that there is no need for bulk skilling of workers in those areas we discussed as skills for innovation.

An alternative explanation, and one we canvassed earlier, is that in some areas skills for innovation are being learnt on the job and through ongoing training courses rather than through formal qualifications. Dalitz, Toner and Turpin found in their case studies that the actual skills for innovation are learnt on the job, although based on what was learnt formally. In mining and computer games they argue that specific skills and competences are more relevant than full qualifications. This may also be the case in the retail sector, where we saw that the majority of employees don't have post-school qualifications.

This leads on to another crucial point, in that innovation takes place in the workplace and the leadership and workplace culture is an important factor influencing whether innovation occurs or not. Misko and Nechvoglod in their paper point out that, if the leadership culture does not support innovation, it will not occur, regardless of the skills available from the workers. This could mean that the skills that workers bring to the job are underutilised. So while we can argue about the importance for innovation of learning in the workplace, we need to be mindful that in reality this does not always occur.

The role of government in facilitating innovation

Governments have a role in the provision of basic education and training. At a systemic level research such as that undertaken by Dalitz, Toner and Turpin indicates that it is important for workers to have strong foundation skills and underpinning knowledge. The Cutler review of the national innovation system states that human capital is central to innovation and that high-quality human capital requires attention at all levels of education. In particular:

Innovation is fundamentally a people-driven exercise and a nation's capacity to innovate is inextricably linked to the breadth and quality and focus of its education and training systems.
(Cutler 2008, p.45)

The government's role in innovation beyond the provision of basic education and training is more contested. Some would argue that governments should promote experimentation in businesses where there is market failure or poorly defined property rights as these can lead to improvements in productivity. Of course this means tolerating failures as well as successes. Further to this, governments could facilitate experimentation in cases where it would not occur if left up to individual businesses, for instance, through tax incentives.

Another role for governments might be in raising awareness of the role VET can play in innovation. We argued earlier that the VET sector can provide trade and technician training that is important in the innovation process, but it also provides training in business, finance and marketing (although this not necessarily recognised by employers). One way governments can assist here is by involving VET practitioners in innovation councils, industry skills councils, or in policy development.

A more indirect way governments can assist is by gathering evidence that will inform target areas for qualifications. Much of the policy discussion focuses on increasing the qualifications of the workforce, but this is done in a rather blanket way. For instance, the Council of Australian Governments (COAG) has specified targets for VET qualifications by 2020—halving the proportions of 20 to 64-year-olds without certificate III or above qualifications and doubling the number of diploma/advanced diploma qualifications (Council of Australian Governments 2008). Although the areas to benefit from this expansion in VET qualifications are not identified, COAG

aims to ‘ensure increased utilisation of human capital’ (p.6). Nevertheless, skills underutilisation resulting from an increase in the proportion of qualifications in the workforce could occur. We discussed earlier that varying skills are needed in the innovation process, depending on context, so a more subtle analysis of demand for skills could provide information on skills (as opposed to specific qualification levels) specifically targeted at improving innovative capacity.

Although we have pointed to areas where governments have a role in facilitating innovation, it could be argued that competition between firms offers the best prospect and that governments should have minimal involvement. This is a valid argument to some extent, but even in this context governments still have a role: by way of example, government regulations that encourage rather than inhibit innovation, for instance, intellectual property regulations responsive to the needs of smaller economies. In general, the Australian Competition and Consumer Commission (ACCC) plays a role in promoting competition in the marketplace and ensuring compliance with competition regulation.

What can we conclude?

We have seen that innovation has become a multifarious concept, extending far beyond traditional notions of research and development, to include operational and organisational processes and marketing. As a consequence there are more broad-ranging implications for the skills required in innovation. Indeed, if we refer to the ABS innovation survey and other case study work (such as that by Misko and Nechvoglod in this book), the types of skills that loom large tend to be less technical skills, for example, marketing. That said, there is no suggestion that this is a straightforward or linear process. Innovations take time to play out and the way skills are used is not always clear.

Despite this cautionary note, we argued that the VET sector has a potentially significant role in this. VET is obviously well placed to deliver initial training in trades and technician occupations, but it can also provide initial training in areas such as marketing, finance and business management. The issue is convincing employers of this. What is also apparent is that ongoing training and workplace training is crucial—provided the firm and leadership culture facilitates it. We concluded with some suggestions about roles for government, even in the context of the primacy of market competition.

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Building up the innovative capabilities of workers

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This chapter discusses building up the innovative capabilities of workers and craftsmen from a theoretical and practical perspective. The theory deals with two different innovation concepts: the importance of work process knowledge and the experiences of workers. Attention is paid to innovation in terms of the wider or extended economic implications of innovation and particularly how these affect the involvement of workers in the firm.

From the practical perspective, the role of *real* work-process-oriented learning in enterprises as a basis for developing innovative capabilities is discussed. An innovative case study is presented in order to explain how working and learning can be simultaneously encompassed, without either of the aspects being neglected. The case is then analysed using a specific (self-)evaluation tool in order to study the relationship between efficiency and apprenticeship training quality. The paper ends with several recommendations for innovative learning environments that enhance the innovative capabilities of skilled workers.

Change of understanding of innovation and the making of innovation

The notion of innovation is multifaceted, because it not only involves new ideas or the invention of artefacts but also refers to organisational, technical and market aspects and to products that are successful in the market. Apart from this, innovations could be also thought as ‘changes’—such as the practical implementation of ‘new’ concepts for company organisation, for example, like group work in the field of car production. This example may underscore the fact that the ‘making’ of innovation is influenced not only by the organisation but also by the people in it: from the perspective of workers, for example, group work may signify an improvement when compared with their previous working conditions. For production planning engineers, however, the expected benefits may fail to materialise—too small an increase in productivity is generated (Manske et al. 2002).

It is for these reasons I would like to use the term ‘innovation’ to encompass a broader understanding in determining whether relationships between innovation and the vocational education and training of workers can be identified. The notion of innovation as a social process which includes many different actors is widely accepted in innovation research (for example, Lundvall 1992; Morgan 1997). In the classical understanding of innovation as a process whereby companies develop and commercialise new products or launch new processes in order to improve product quality or lower the production cost, the view of innovation was limited, in that engineers were *the experts for innovation*. But by applying a broader understanding, innovation is not only

influenced by the engineers but also by the workers—apart from other internal and external actors. But before we come back to the role of workers within the innovation process, we will examine the influences from outside the company organisation.

It was the work of von Hippel (1988) on the sources of innovation that drew attention to hitherto unrecognised innovation actors outside the company: *users and suppliers*. In von Hippel's case studies key users of the machinery or aircraft industry had the opportunity to bring their mainly practice- and experience-based expertise into the development process, and, similarly, supplier companies were given the chance to include manufacturing and material know-how into the overall innovation process.

These tendencies have nowadays developed further, towards innovation networks (Duschek 2004), which include not only the suppliers and customers mentioned above but also research organisations or universities (Deitmer & Attwell 1999). The networks can take different forms: either intra-organisational or inter-organisational; they can either be local and regional, national or international; their communication and cooperation can range from direct contacts (regular meetings), to virtual/electronic communication and collaboration; or a mix of these forms. Finally, the innovation networks gather a wide range of people from different educational and professional backgrounds. These different actors contribute different types of knowledge, skills and expertise, all of which add new dimensions to innovation processes. Furthermore, the evaluation of such networks requires different methods to cope with the complexity of viewpoints in this new conceptualisation of innovation (Deitmer et al. 2003)

But back to the workers: an important step in opening the innovation arena for these actors was setting the target for *design to manufacturability*. This meant leaving the sequential track, which saw the manufacturability of a new product as the final problem to be solved (if targeted at all).

The evidence for the inclusion of workers lies in history: many breakthrough innovations have not been made by engineers or scientists, but rather by technicians or highly skilled craftsmen and workers. As an example, we might think of technological progress before 1850, particularly in the case of the steam engine, which was developed and produced by craftsmen and skilled workers or technicians who deployed a knowledge that originated from practice rather than from science (Mokyr 2002; Rolt 1986). Similarly, practitioners developed the transistor by advancing by trial-and-error methods, which eventually gave a result (Braun & MacDonald 1978; Rosenberg 1982; Senker 1993).

It was the Japanese who taught the world that manufacturability is a primary goal of product innovation and that in order to ensure a high level of manufacturability, the production planning and shop floor people needed to be included in the very early stages of the innovation cycle (Imai 1991). This realisation widened up the formerly closed 'monastery of design monks'—with the engineers as key innovation actors—to a 'lively bazaar' of many actors with diverse backgrounds and a diversity of design and innovation goals.

Since knowledge creation is widely accepted and studied as a core activity of innovation (Nonaka & Takeuchi 1995; Nonaka & Nishiguchi 2001), the focus of the following paragraphs will be on knowledge capacity development and particularly on knowledge sharing.

Shared knowledge is one of the important resources of successful innovation. Therefore, the organisations, networks or teams which have established the best structures and methods to develop a common understanding among individuals representing different functions (organisations or disciplines) are those with the best innovation performance and thus with competitive advantage (Hong et al. 2004). The synergy of shared knowledge cannot easily be achieved, because knowledge does not have a unique nature. There can be different 'cognitive universes' between organisations or departments and there can be incompatible knowledge domains between departments or teams; knowledge can be tacit in nature and thus difficult to

codify or to make explicit (Senker 1993); and eventually, a lot of knowledge is 'sticky', that is, held by individuals and cannot be separated or objectified. Thus we observe many obstacles to knowledge sharing which prevent it from being a planned process. But nevertheless, some good practices with regard to knowledge sharing are reported (for example, Nonaka & Teece 2001; Harryson 1998).

Kevin Morgan (1997) pointed out the interactiveness and the multi actor-based character of innovation processes: 'There is now growing support for the view that innovation is an interactive process between firms and the basic science infrastructure, between the different functions within the firms, between users and producers on interfirm level and between the firm and the wider institutional milieu and that this process should be conceived as a process of interactive learning in which a wide array of institutional mechanisms can play a role' (Morgan 1997, p.493). The economic studies of Hall and Soskice (2001) make clear under which conditions and areas this new character of innovation is needed when they summarise that 'incremental innovation is getting increasingly important for the global competitiveness of companies ... in such industrial areas where high sophisticated industrial machinery; innovative tools or other process automated production machinery, automated transport systems and high quality engines are produced'. The authors state that for 'cutting edge' products there is a need for incremental innovation in the manufacturing field and this has an impact on the skilling of workers. We will pick up this point again in the next section.

Taking into account the circumstances outlined above we can consider five influential key aspects of contemporary innovation (Ruth & Deitmer 2010) in relation to the involvement of workers in design and construction work:

- 1 The idea of sequential innovation steps: this means that engineers are responsible for innovation and they follow the following sequence: from concept design, system design, detail design, prototype testing, refinement and manufacturing. In this action model the manufacturing undertaken by workers is at the *end* of the innovation process.
- 2 The concept of innovation in a new understanding transcends the 'expert model' and brings the workers much earlier into the debate. Their feedback into what is planned by the engineers is considered highly relevant because it entails information about the *manufacturability of the concept design before further design details are undertaken*.
- 3 Thus the assumption that *radical* innovation is based on (theoretical and scientific) knowledge and that *incremental* innovation thrives on skills/experiential knowledge is nowadays increasingly obsolete. Moreover, the difficulty in distinguishing radical from incremental innovation should not be ignored. The distinction between radical and incremental innovation will be difficult to maintain in the future, if trying to determine *the role of practical knowledge and the experience of workers in innovation processes*.
- 4 The evolution from sequential to concurrent (or at least overlapping) innovation phases, as noted above, exerts an important impact on the necessity for sharing knowledge. The knowledge and experiences that are available in functional areas at the end of the formerly sequential innovation process (for example, manufacturing expertise, but also suppliers' capacities) are now required at the early stages (concept design) and during the ongoing innovation process. Knowledge sharing between the manufacturing and early design stages is essential, with the *need to bring workers' knowledge into the design process*.
- 5 Researchers from both human resource development and from innovation theory have failed to make the critical link between *situated learning* (Lave & Wenger 1991) and innovation as a *social process* (Lundvall 1992). By treating innovation as a technologically determined process and by treating learning as a largely technical and individual matter, learning is rarely seen as integral to the process of innovation. However, knowledge networks bound by professional and spatial dimensions are critical to the process of the transformation of tacit knowledge to practice and innovation. In fact innovation can be considered as developing from the continuous and dynamic interaction between implicit and explicit knowledge (Nonaka & Takeuchi 1995). The

lack of research into the interrelationship between situated learning and innovation as a social process is a potential constraint on innovation. Thus, there is a need for research to examine these interrelationships and develop a better understanding of the learning dimensions implicated in innovation networks or companies (Corbett, Rasmussen & Rauner 1991; Deitmer et al. 2003).

The following section discusses this new understanding of innovation in terms of economic implications. Here we will examine the change towards a leaner and less hierarchical production concept and how this is driven by the post-Fordist economies.

Change of production technology and paradigm

Why a new production concept? What are the consequences for workers? What kinds of skills are needed for such innovative workers? What are the consequences for the innovative organisations?

Post-Fordism signifies the beginning of a new industrial era, one associated with contemporary dynamic economic development and which has, apart from its desirable impacts, severe consequences for the vocational training of workers. This new era is creating a better dynamism in advanced industrialist countries, which, due to the international global market have found it increasingly difficult to compete on the price of manufactured goods alone. Instead of mass-producing products cheaply, the competition between companies in a post-Fordist era arises from additional non-monetary factors such as the unique quality, design and technical performance of the products, including timely responsiveness to the needs and wishes of the individual customers (Koch 2006).

Customers wish to receive more moderately priced tailor-made products. This sounds contradictory because one-of-a-kind products sound expensive, but their manufacture has to be achieved cost-effectively. To follow this paradigm the factory becomes leaner and allows skilled workers to make more decisions, thus reducing hierarchy levels. Such a production concept is based on the availability of skilled workers. The worker qualifications within such an environment are enriched—from a small skill profile towards multi-skilling.

The post-Fordist model is possible because information technologies have advanced over the years to allow just-in-time manufacturing of high-quality products. There is no longer a need to stock up on a given product. Products are made on demand and then they are out the door. The key to production flexibility lies therefore in the qualifications of the workers and in the use of smart production technologies, which allow direct intervention and control by workers. One of the major results of the new electronic and computer-aided production technologies is that they permit rapid switching from one part of a process to another and allow—at least potentially—the tailoring of production to the requirements of individual customers. Instead of a single firm manning the assembly line from raw materials to finished product, the production process becomes fragmented, as individual firms specialise in their areas of expertise.

Table 1 illustrates the changes of innovation management within the company and the consequences for the skilling of the workers. This change within production philosophy can be described as a move from a top-down management approach towards a participative management approach (Rauner, Rasmussen & Corbett 1988; Deitmer & Attwell 1999).

Table 1 Innovation management and the skilling of workers

Innovation management by control	Innovation management by participation	Organisational consequences for the skilling of emerging workers
Function-oriented Tayloristic work organisation	Business-oriented work organisations	Learn to work within the flow of the business process and at the workplace by experience-based learning
Distinguished hierarchy	Flat hierarchy	Self-regulated working and learning based on methods like plan, do, act and control cycle
Low fragmented qualifications	Shaping competences	Able to shape workplaces and make suggestions for improvement of products and production processes
Executed work	Commitment, responsibility	Develop vocational identity and occupational commitment
Quality by external control	Quality consciousness	Professional level of training based on key work and learning task

It can be noted that a work environment in which the workers plan, control and validate their own work task can be a competitive one. However, it is also necessary that workers have the ability to make incremental and continuous improvements to the manufacturing process to achieve better products. As part of this understanding the worker has to communicate regularly with engineers. Equipped with multiple skills, including the ability to assess the quality of products, they must be able to confer about the possibilities for improvement. In the context of improvements to the manufacturability or the ‘design-to-assembly’ quality of the different products, communication skills for interacting with planners or engineers are needed. Therefore it can be said that the worker needs to possess ‘holistic skills’ (Rauner 2007).

But how can we access and identify good practice exemplars from production firms, industrial enterprises and companies? How can we differentiate between good and less good cases in order to highlight the conditions necessary for an innovative learning environment, including the attitudes and roles of the different actors within an innovative scenario? Here new evaluation methods can help. These should allow an assessment of the learning dimension in such production environments and identify how the key actors, such as apprentices, workers and engineers, are best accommodated. A comprehensive evaluation of work and learning may also include those effects that are difficult to identify and cannot be measured directly. These key actors (including, for example, trainers responsible for work-based learning environments, as well as the apprentice as a learner) could be invited to evaluate their own work and the learning activities of their production work, with support from an external VET researcher. The actors are encouraged to make explicit how they perceive their work in terms of important criteria: management, communication and learning. In this way the future focus of innovation management activities can be identified.

The following illustrative case study is analysed in order to highlight key management lessons for the innovative training of emergent workers. By applying a specific research instrument the quality of the apprenticeship in terms of its relationship between innovativeness and effectiveness can be studied. But first of all I would like to present the case and then the tool which allowed the identification of good practice.

An innovative case from the German manufacturing industry: lessons to be learned

This German manufacturing company was founded 40 years ago by an innovative mechanical engineer. Stimulated by his former manufacturing and design work in the food processing industry, he began to develop packaging machinery in other application fields. The idea was to use steering

and control technologies to a greater extent and to apply similar automated processes to the packaging of diverse consumer goods, like computer disks or pharmaceutical products. In a statement the company claims to use cutting-edge technologies, emphasising that they are flexible in the design process in relation to the special wishes of their clients. Each of the products can be tailored to the needs of the industry clients. Their products include cutting-edge tools with which customers have been extremely satisfied and which are now widely used around the world. Customers specify their requirements in relation to the timeline, reliability and robustness of their machinery. Therefore, the success of the company and its future are dependent on the creativity of the engineers, but also on the manufacturing and service skills of its workers. All of them are skilled workers and have undertaken an apprenticeship of at least three years in occupations such as industrial mechanic, toolmaker or electrician.

Because of its increasing turnover and expanding sales figures, the company has grown over the years to become a medium-sized company with around 300 employees. Fifty per cent of the employees are involved in manufacturing, while 21% of the company staff are involved in the construction and design of the products; engineers and technicians are mostly recruited for this purpose. In many cases the engineers began their careers as apprentices. The number of management and administration personnel is small, at around 17% of the workforce. Apprentices represent 6% of the company employees.

The apprenticeship model in technical and commercial occupations was used in the company right from the start, beginning with industrial mechanic in 1969 and industrial clerk in 1994. New occupations like mechatronic and process mechanic for plastics and rubber technology came into existence in 1999 and in 2006 respectively. The apprenticeship is supported by additional study at the local technical vocational school, with a normal apprenticeship lasting for three-and-a-half years. The apprenticeship includes theoretical and practical exams at a chamber of commerce and trade in the presence of a regional experts commission comprised of company representatives and technical or commercial vocational school teachers.

But what makes the apprenticeship training at this company so different from other German companies and why can it be regarded as innovative and good practice by comparison with the apprenticeship practices of other companies?

The apprenticeship training conducted at this company is unique because a number of key principles inform the understanding of the trainers and co-trainers as well as other technical workers in the company. The following three key principles of the training organisation are discussed and widely implemented within the company apprenticeship training.

First lesson: 'Our apprentices are in the middle of company action'

The apprentice has a direct role in the everyday production and manufacturing of the complex products in the assembly hall, as well as in all the workshop departments. This means that the apprentices follow the production process through the company. It can be claimed that apprenticeship training is part of the everyday business of the company. The apprentices are present in the production process and visible to the other workers and make contact with internal and external customers. Therefore, the apprentices are expected to integrate well into the company's daily activities. An apprentice road map is defined for the company trainers, in which is laid out what kind of key working task can be learned within each production unit or department. This allows better monitoring of the increasing demands placed on the apprentice as he or she gradually increases his/her competences. After an intensive basic training in cutting, filing, drilling and undertaking some training projects, the apprentices work directly in the production process and are supported by the 'masters of craft' (*Meister*). Thus, for around 80% of the training time the apprentices work in the production process.

Second lesson: ‘Our apprentices work on our products as early as possible’

This second principle encourages the apprentice to get in touch with real company orders and the handling of related products and machines at an early stage, which should enable them to develop a better understanding of the importance of the production quality of the various components to the quality of the finished product and how this can be best achieved. In this way they learn about the involvement of the key actors and the various roles they take during the planning, manufacturing and maintenance or servicing of the product. With such a business process overview and a comprehensive understanding of the production process, the apprentices are later well qualified for service activities.

The company is highly export-oriented and often has to send skilled workers to work abroad (assembly of products, introductory measures and maintenance). Therefore, apprentices are expected to acquire sufficient skills in English as a working language.

Third lesson: ‘Sharing of knowledge between manufacturing and construction and design is one of our key assets’

The company employees understand this key lesson as an approach to establishing a strong relationship between engineers and workers. This means that working with the engineers is not a one-way street, but is more an understanding or dialogue between partners. One partner is more responsible for the design and construction of the production machinery, whereas the other partner takes on the role of manufacturing a high-quality product. During the vocational training of the workers an intelligent dialogue between skilled workers and engineers has to be established right from the beginning, and the process, from design to manufacturing, has to be understood as early as possible. This means that the apprentices are also partly learning the task of designing products and of constructing via CAD etc. During the apprentices’ active learning tour, or their work experience journey through the company, they are supported by a stay of up to perhaps several months in the design and construction department. However, this is also complemented by apprentice learning on company action projects. These are small projects that take place within the first apprenticeship training year and which allow a team of apprentices to undertake their own construction and design work. Through these learning routes the apprentices learn to give feedback to engineers, for example, an assessment of the appropriateness of the product for manufacture.

In the next section I want to show how this case was identified and selected as one of the strongest by comparison with several other cases. I will also describe the evaluation methodology used to assess the case. The learning arrangements of this highly competitive case study enable us to offer recommendations for innovative training management.

The evaluation methodology—the QRC tool—was developed by the Bremen University research group for innovative vocational training.

A tool to analyse the quality of in-company training: the Quality, Returns and Costs Tool (QRC)

The QRC (quality, return, and costs) Tool enables companies to self-estimate the cost-effectiveness as well as the quality of their apprenticeship training activities. The tool, which can also be used in VET research, is based on concrete key questions to trainers and co-trainers. In the first set of questions the exact cost of the training is collected. Major cost factors such as the apprentices’ and trainers’ gross wages (including social benefits etc.) are collected by the trainers. Other operational costs are added; for example, the costs of any teaching and learning materials, as well as training machinery or other equipment for learning used in the company. Further expenditure items include

fees to be paid to industrial bodies, costs of professional clothing and any external training costs at special training centres.

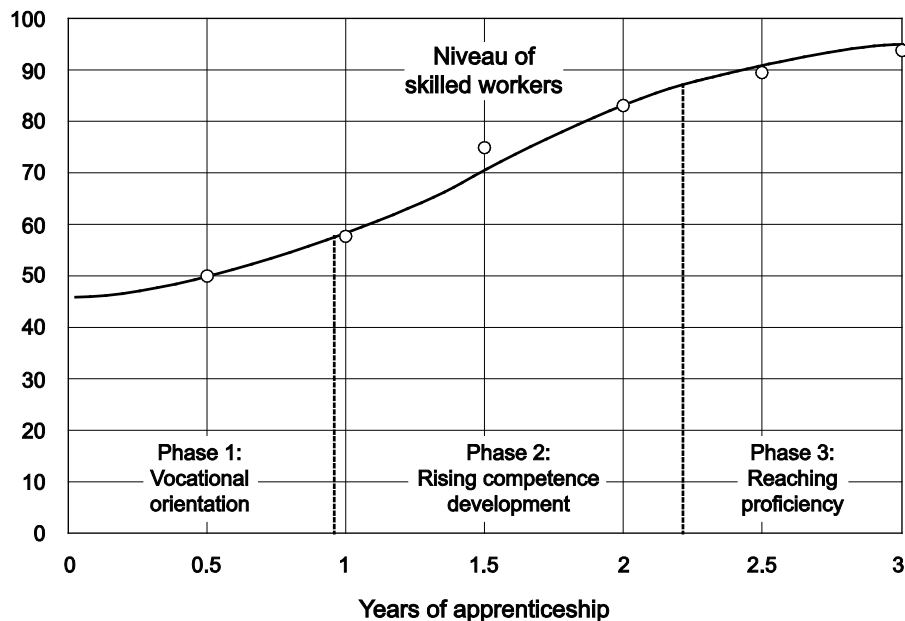
To assess the benefits, the existing cost–benefit model is expanded. Benefits are measured according to the productivity of the apprentices during the times they are actually working in the company and carrying out work tasks. This productivity itself is measured as a percentage of the productivity of skilled workers.

Apprenticeship quality is evaluated on the basis of six main criteria and subsequent indicators are derived from these criteria. The key criteria are derived from vocational pedagogy:

- ✧ *Learning in the workplace by experience-based learning*: this takes into account the number of real duties undertaken and is a percentage reflecting the apprentices’ abilities in relation to becoming a fully skilled worker over the three-year apprenticeship (see figure 1).
- ✧ *Professional level of work task*: this is determined by taking the average examination results of the apprentice’s final test of practical skills and knowledge and the time needed to become acquainted with the professional field after the apprenticeship.
- ✧ *Degree of self-regulated learning*: this criterion investigates the relationship between detailed assignments and students’ autonomous work on business orders.
- ✧ *Learning in the work and business processes*: this covers apprentice participation on work assignments which are part of operational business processes.
- ✧ *Professional competence*: this is measured as the level of professional competence reached through company training activities.
- ✧ *Vocational commitment*: this covers the apprentice’s commitment to work; attention paid by the apprentice to quality when accomplishing work tasks and orders; and the way the apprentice or trainee finishes their work task responsibly.

The first four indicators represent characteristics of the training process itself. The last two criteria are related to the effects the training process has on the apprentices, his or her commitment to the occupation, as well as their professional competence, which is seen as an outcome of the training process as a whole.

Figure 1 Increase in apprentice productivity during the three years of training



Source: Rauner and Heinemann (2009).

After answering this set of questions the tool generates visualisations (spider-web diagrams and other diagrams, like bar and line charts) that make it possible to visualise the quality of training in the particular company by enabling the company to self-estimate costs and returns and the quality of the apprenticeship. Apart from this, the tool allows comparisons of data between different kinds of companies and their apprenticeship programs. Therefore it could be said that the QRC Tool has a double function: diagnosis and research.

QRC results on this case and in regional studies

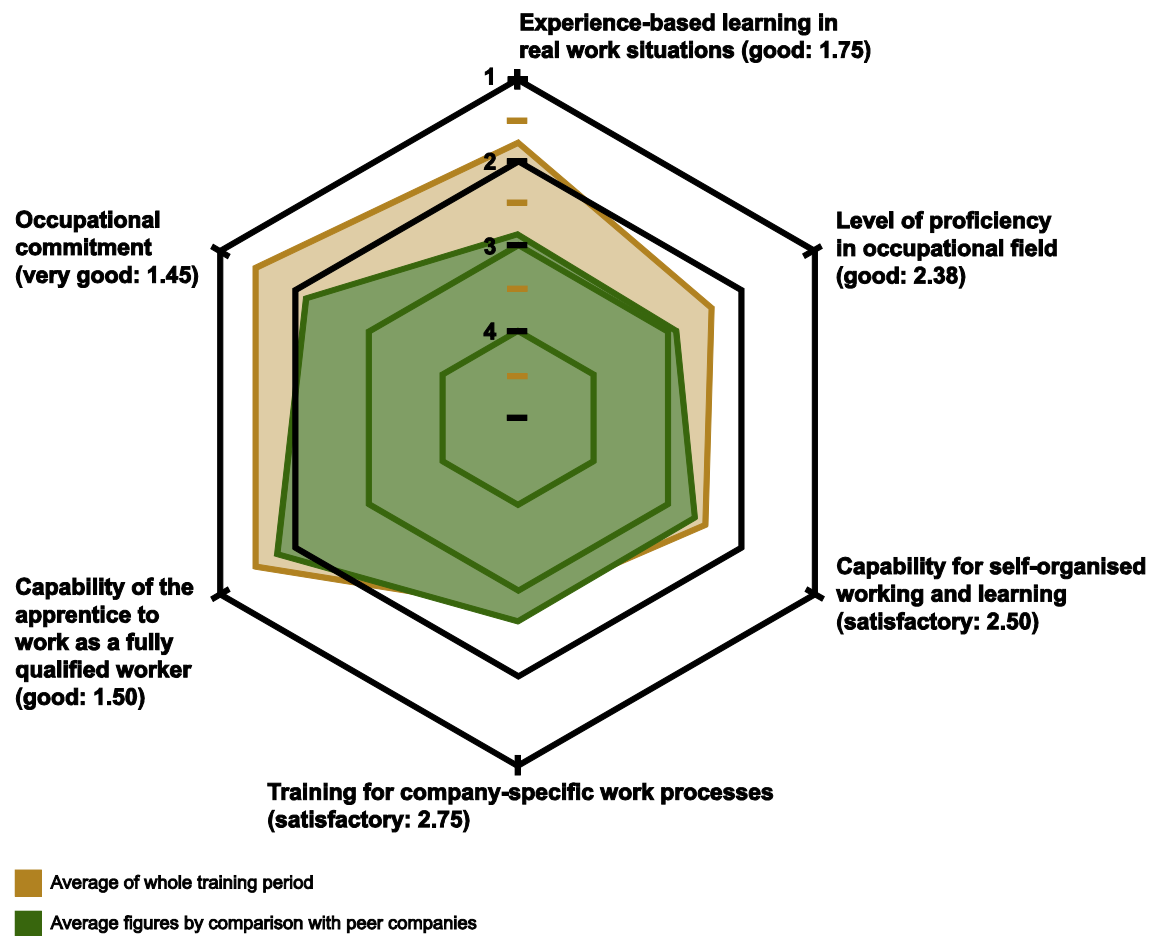
With the help of the QRC Tool and with additional inquiries (like interviews) this company case was examined. Using the questions in the QRC Tool the responsible trainers in the company evaluated the quality issues associated with the cost–benefit ratio of the training. This provided a deeper insight into the main characteristics of training in this company. The QRC Tool identified that there is a positive rate of return (13%) from the training activities undertaken by the company and also if the working and learning tasks were further integrated at the various workplaces, this rate could be improved—increasing to 23%. In general the productivity of apprentices in this company is above the average level when compared with other companies in the same occupational field. The main quality features are the strong emphasis on self-organised learning and the incorporation of learning and learners into the production process. This assessment is supported by the fact that apprentices and trainers rate the quality of training in a similar way.

In terms of apprenticeship quality at this case study site, the analysis of the self-evaluation results shows that major differences occur first of all between the first and the second years of the apprenticeship. In the first year apprentices have difficulty undertaking directly productive jobs. The cost is too high when apprentices make mistakes—because they have not learned enough during the first year of the apprenticeship. But the apprentices in this case study reach much higher quality standards as their professional competence and independent learning and working increases. The apprentice in this highly innovative apprenticeship case study learns to carry out demanding work and learning tasks that support the development of autonomy. The result is a relatively fast acquisition of competence, along with higher occupational commitment, as well as the achievement of higher levels of professional competence. But, as was noted, if the apprentices worked more directly in the production, the effectiveness of the training could be increased. Therefore the in-house instruction through extra training activities—apart from the production line—could be optimised in such a way that more working time is made available directly within the production process. This kind of setting provides more experience-based learning for the apprentice and at the same time the apprentice becomes more productive.

In contrast to this, a good proportion of the other companies taking part in the regional self-evaluation still indicate that there is significant potential for increase in competence and productivity and further development in relation to their training organisations (figure 2).

Figure 2 The apprenticeship training quality of the case study by comparison with other training companies in the same occupational area (industrial mechanic apprenticeship training)

Quality diagram – Quality Index QA: 2.54 (satisfactory)



QRC results on a the level of a regional study by examining more than 170 companies

In an analysis of the results of more than 170 companies by using the QRC Tool in the industrial region of Bremen, Northwest Germany, the IBB research group discovered that, on average, the apprenticeships produced net returns (Rauner, Heineman & Piening 2008; Heinemann & Rauner 2009). In fact, some 55% of the companies that took part in the self-evaluation realised net returns. The companies' actual net returns vary, with some companies gaining more than 10% net return per apprentice over the full training time.

But another important aspect was analysed by the group and shown by the study: the higher the quality of the apprenticeship in the particular company, the better the returns from the apprenticeship engagement. This shows that the company itself can influence efficiency by the way it organises the apprenticeship. In the same occupational field there are quite considerable differences between the various companies studied. High-quality apprenticeships do not only benefit the apprentice; they are also worthwhile for the company in purely economic terms.

Some concluding remarks

- ✧ *Maximise learning outcomes during work on company work orders:* to enhance the innovative capabilities of workers it is important to start by building innovative capacities through learning from work experiences. This means that from the beginning the apprentices are confronted by real work and learning tasks (WLTs). Work and learning tasks are integral parts of the company's business processes. As in our good practice example, this is done by maximising the learning time within the production department insofar that learning for apprentices in learning workshops or training centres resides in a real work task and not in special learning task. But to create a leaning climate it is necessary for apprentices to be in the 'centre of the action' and to take part in the business process. But to get this done, a kind of internal 'road map' has to be developed for the apprentice by the training management within the company.
- ✧ *There are different kinds of work and learning tasks—beginners, advanced beginners, advanced and young experts:* the work and learning tasks have to take place in a certain order; this means there are work and learning tasks for beginners, advanced beginners, beginners and young experts. Obviously, the most difficult tasks should not be at the beginning of the learning career of the apprentice. The principle for ordering the WLTs in a training package for the apprentice program (road map) is building on his/her prior knowledge. The collection of WLTs in a training plan therefore displays an increasing complexity. At the beginning there are more experiences which allow orientation; later more detailed work process knowledge is built (Rauner & Haasler 2010).
- ✧ *Comprehensive work tasks with planning and preparation as well as assessment after work completed must be arranged:* all work tasks to be included in the apprentice training package should be verified by the trainer to ensure that comprehensive work tasks are undertaken. This means that the apprentice learns to do the job in its entirety, but the apprentice also needs to understand other quality-assurance activities like planning the work and preparing and assessing the work done. The full documentation of the work task undertaken should be included. This also covers feedback on the work activities, whereby work steps are discussed with planners and engineers. The manufacturing of the products has to be discussed as openly as possible to determine whether the quality of the product can be met, or if not, where the difficulties and hindrances lie.
- ✧ *WLTs are a part of the company's business process and are based on common quality standards:* the work and learning tasks must be arranged in a systematic order, and not arbitrarily. For the trainer it is therefore important to consider which learning and work tasks are appropriate for the current status of the apprentice. In some company learning cases it may be advisable for the trainer to plan a deeper investigation of his company. A questionnaire or an investigation grid with the most important aspects to be adhered to could be utilised. Such instruments turn a non-systematic visit by the trainer into a target-oriented investigation. It is therefore important to capture details at the workplace and to interview other workers for further ideas. The most relevant points will be the verification of the work tasks for the apprentice. The trainer has to coordinate this kind of investigation with the company management in order for these measures to be supported and to obtain the necessary financial backing. It must be emphasised that all activities relate to obtaining more information about work tasks.
- ✧ *WLTs should force apprentices to cooperate with colleagues and departments:* the basic idea of the WLT concept is to develop complete units of working and learning that match the practical skill needs of work-specific tasks and which, although covering a complete task, build upon each other, and in total cover the complete business process (Howe et al. 2002). WLTs not only describe the object of the work, work methods, work instruments and other requirements, they should also look for learning through others and in cooperation with others. Therefore the social and cooperative situation in which the WLT is embedded is important. The apprentice may be encouraged to cooperate with other apprentices and with colleagues and also learn to talk with the design and construction department at an early stage. This can help to enrich his/her innovative capabilities so that he/she is able not only to undertake work but also to talk about work and the effects of work on the completion of the complex technical product.

- ✧ *Keeping a training log book is learning in itself*: this instrument helps to develop experience and supports self-directed learning. What was learned and what could be learned in the future become clear more quickly. An important function of the training log book is not only that it provides complete documentation of the key work task of the apprentice but it also allows reflection on his/her experiences. This forces him/her to answer questions like: What were the challenges of the work task? What have I learned best so far? Where do I still see problems and difficulties? How do others see my work and work results? As we can see, these questions do not resemble a personal diary but are more like the personal estimations and assessments of the apprentice him/herself. They pave the way for talks with the company trainers, on which a good basis for dialogue about the shift of self-assessment towards external assessments can be built (Rauner & Haasler 2010).
- ✧ *Self-assessment of individual learning makes external assessment by others necessary*: the self-assessment of the apprentice in relation to his learning progress makes external assessment by others also necessary. Those people who accompany the learner apprentice in the company may give feedback and advice and may be trainers or merely colleagues in the workplace. An important element of this dialogue is the *competence assessment sheet*, which makes the achievements of the apprentice transparent (Deitmer & Ruth 2007). With competency made visible through this sheet and especially if accompanying the apprentice, when the apprentice becomes aware of his or her own competences a process of reflection and self-reflection about his/her own competences, as well as the desired competences to be acquired during the mentoring process, can begin. This requires a broad knowledge of domain-specific and domain-independent competences on the trainer's part, which is yet another indication of the necessity for employing company-internal trainers who have a strong knowledge of the work processes and the specific subject fields. The challenge is how to match the wishes (of the individual) with the needs (of the company) and how the balance of individual wishes and institutionalised needs can constitute a career-advancement track to the benefit of all the actors involved.
- ✧ *The use of tools (QRC) can help to support and analyse*: the QRC Tool (Rauner, Heinemann & Piening 2008; Heinemann & Rauner 2009) is primarily an instrument for companies and responsible trainers or part-time trainers to (self-)evaluate the quality and cost-effectiveness of their company's apprenticeship training. The major cost factors for workplace training are the salaries of apprentices (which cannot be influenced because they are externally negotiated). The benefits are measured according to productivity during the times the apprentices are actually working in the company and carrying out the work tasks of a skilled worker. The QRC Tool is an applied research tool that allows the examination of workplace training in industrial companies. However, it also allows analysis of the most innovative practices in order to stimulate debate involving companies and VET research.

Prospects: can TVET systems be transformed into a 'pillar of innovation' beside enterprises and R&D institutions (for example, like universities, laboratories)?

Production processes that are simultaneously inbuilt learning environments should possess the following two characteristics: a corporate culture that facilitates cooperation and communication between all relevant innovation actors, particularly including those 'players' who have practical experience; and a balance of theoretical and practical learning integrated in every phase of the vocational training in a scientific apprenticeship (dual integrated bachelor with practical expertise).

I would like to end this paper by referring again to Hall and Soskice (2001), as they state: 'Incremental innovation works best ... when the company management takes priority in creating: stable and secure working places, more workplace integrated control based on worker intervention instead of external and cost demanding control mechanisms and then also allows employees to take semi autonomous self responsible decisions within their production environment'.

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Neuroplasticity and its application for skills in innovative workplaces

David Rumsey

David Rumsey and Associates

This chapter examines the concept of neuroplasticity and how it can be applied to skills in innovative workplaces. More particularly, it examines how neuroplasticity can assist older workers to maintain relevant skills and also how other workers can obtain new skills sets over their career. The chapter also examines what this means for training in VET and other education sectors.

Introduction

What is an innovative workplace?

An innovative workplace is difficult to define. Innovation in a workplace can embrace a wide range of dimensions, including the products or services involved, the processes for achieving and delivering the products or services, the markets that the workplace serves, the way the workplace is organised and managed, and the research and design strategies used to identify the innovation directions and objectives it pursues.

What appears to be central to innovative workplaces is that they are engaged in the ‘exploitation of an opportunity for advantage’. The opportunity may become available through access to a new technology or a new application of an existing technology. It may arise through identification of more efficient and flexible production methods, such as lean manufacturing systems or processes that utilise emerging technologies. The opportunity may be created through careful and strategic marketing, perhaps looking to market globally or targeting a niche market, or even deliberately engineering an entirely new market. In some innovative workplace scenarios, the opportunity lies in the area of organisational management, including novel human resource strategies, vertical integration along a supply chain, or horizontal integration of service or product delivery. It may involve novel franchise arrangements or distribution systems.

Despite the diversity of ways in which innovation can be realised within workplaces, a key element of each of the workplaces is the requirement to have a workforce in sufficient numbers with the capability, flexibility and commitment to contribute to the organisation’s operational objectives. The very diversity of innovative workplaces inevitably means that there are a myriad of different skills sets needed.

In the modern economic climate, there are many challenges for innovative workplaces in ensuring that they achieve and retain a suitable workforce with the necessary skills sets, along with a commitment to contribute to the organisation’s ongoing pioneering operations. No two innovative

workplaces are likely to have the same mix of skill requirements, which means each workplace needs a flexible, adaptive approach to recruitment and skills development. Given the current tight labour markets and a labour force demographic dominated by workers approaching retirement age, just retaining an existing workforce and having viable succession planning are critically important. Even the skills sets required are likely to change over time as the nature of the innovation evolves, requiring workers to adapt and grow through a process of lifelong learning.

Reports of research into the skills needed in innovative workplaces consistently point to the importance of skills sets for innovation that cover a diverse range of cognitive skills and span a variety of occupations, including production workers, tradespersons, technicians, managers, engineers and scientists (Cropley 2005; National Research Council 2008; OECD 2010; Toner 2009). It is noted that the report by the Organisation for Economic Co-operation and Development emphasises that work-based learning forms an important component of a larger pattern of *lifelong learning* encompassing all stages and levels of education:

The importance of work-based learning highlights the fact that skills acquisition is a lifelong process. In addition to formal education through the primary, secondary and tertiary levels, the learning that takes place on the job is a crucial component of skilled workers’ toolkits and helps shape innovation outcomes. (OECD 2010, p.57)

Skills sets for innovative workplaces

Given the diversity of innovative workplaces, what are the implications for the types of skills sets that need to be available for the workplaces to achieve their innovation objectives? Based on a consideration of the literature on innovation, table 1 gives a list of cognitive skills that may be included in skills sets for workers in innovative workplaces. Of course, the combinations and customisation of skills actually required will be dependent on the focus and circumstances of the specific innovative workplace context.

Table 1 Examples of cognitive skills that may be required in innovative workplaces

Observing critically and analytically	Analysing information
Identifying and solving problems	Comparing visual, written, graphical and numeric information
Thinking laterally—including brainstorming and thinking divergently, both individually and in concert with others	Evaluating outcomes
Searching for information using available resources and systems	Planning activities
Synthesising inputs	Organising activities
Creating visual, aural, written, graphical and numeric information	Practising a real or simulated activity
Thinking critically	Operating and maintaining appropriate technology
Filtering (i.e. sorting information on the basis of given criteria)	Role-playing with others (sharing experiences and responses within simulated situations)
	Communicating with others in writing and orally—both face to face and using appropriate technology

A number of these skills correlate with the various generic skills that have been identified as critical across all workplaces. These include the employability skills (identified in the education sector) and human factors (identified as critical for safety management in workplaces). These are summarised comparatively in table 2.

Table 2 Examples of generic skills—employability skills and human factors

Employability skills	Human factors
Communication	Communication
Teamwork	Team-working
Problem-solving	Decision-making, problem-solving
Planning and organising	Planning, organising and formulating strategies
Initiative and enterprise	Dealing with unexpected or unpredictable situations (initiative and innovation)
Self-management	Situational awareness, fatigue management, lifestyle management, morale and job satisfaction
Learning	Technical competence, effective training systems
Technology	Standard operating procedures, standard maintenance procedures

Notwithstanding the diversity of skill combinations that may be required for the effective functioning of innovative workplaces, some recent emerging developments and findings in cognitive science and the neurosciences provide new insights into how cognitive skills may be developed and adapted in ways that have major implications for the formation and retention of effective workforces in innovative workplaces. These developments and findings relate to how the brain grows and develops on the one hand, and the nature of intelligence on the other.

Emerging developments in cognition and the neurosciences

New insights into how the brain develops and how we learn

Throughout the nineteenth and twentieth centuries, it was generally believed amongst those involved in cognition and the neurosciences that the brain was fixed and finite and that its structure became permanently established and ‘hardwired’ during early childhood. During this time, the reported majority opinion was that people’s neurons are developed when they are infants and cannot rejuvenate themselves. In this ‘traditional perception’, the brain regions are dedicated to specific functions, for example, visual information must always be processed by only the visual cortex. Proponents claimed that, once neurons have been developed in the first few years of childhood, they are set for life and from that time forward the neurons gradually die, depending on the extent of their usage, leading to the popular adage with reference to the brain—‘use it or lose it’.

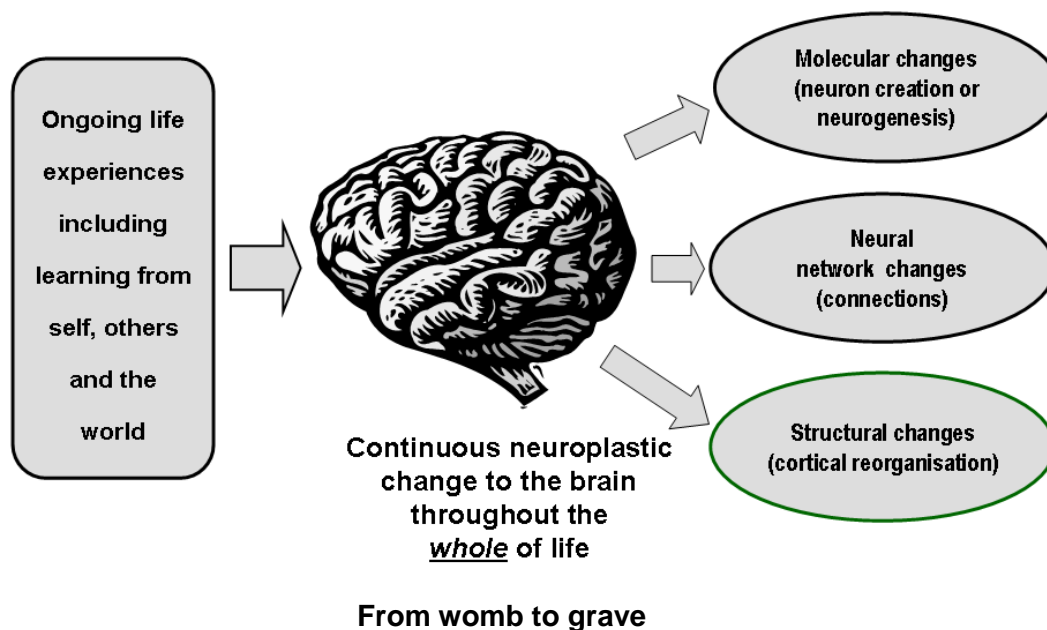
Since the 1960s, aided by the availability of modern imaging and scanning techniques such as MRIs and PET scans,¹ a range of evidence has emerged from neuroscientific research, medical clinics and laboratories that has contributed to an updated view, which now suggests that the brain is not ‘fixed and in gradual decay’ but is in fact ‘plastic’. Over this time, there has been a shift in thinking towards a view that the physical components and structure of the brain actually adapt and are modified continuously throughout life in response to a person’s day-to-day physical, mental and social experiences. This characteristic of the brain is now called *neuroplasticity* (Begley 2008; Dispensa 2007; Doidge 2007, 2009; Kandel 2006; Maino 2009; Merzenich 2004, 2008, 2010; Schwartz 2009; Schwartz & Begley 2002; Steen 2007; Wood 2009).

These changes and adaptations are claimed to occur in a variety of ways (Schwartz & Begley 2009, pp.251–4; Dispensa 2007, pp.145–78): at the molecular or cellular level (neurogenesis—the growth of new brain cells or neurons); at the neural connection or networking level (the way brain cells/neurons connect with each other); and in the way the brain is structured (how different parts of the brain become organised and reorganised to process different cognitive and bodily functions). In the earlier view of the brain as fixed in childhood, the brain was viewed as a cognitive storage

¹ Magnetic resonance imaging (MRI) is primarily a non-invasive technique used in radiology to visualise the detailed internal structure and limited function of the body. Positron emission tomography (PET) is a technique which produces a three-dimensional image or picture of the functional processes in the body.

and processing system, which was established at an early age and stayed that way for the rest of a person's life. Education was seen in effect as 'loading data' into a fixed system but was limited by the structure already established. As people proceeded through their life, the structure and processing capacity of their brains was perceived to gradually decline and disintegrate, with a loss of function and storage capability until, eventually, in older age, dementia and other mental diseases set in and caused the brain to effectively stop functioning. This view has now been superseded. In the current emerging view of the brain, it is recognised that the brain actually changes, develops and evolves continuously from the moment people are conceived until the day they die; that is, true 'lifelong learning'. Their ongoing cognitive, physical and social experiences and day-to-day interactions with their environments involve complex dynamic processes which researchers are continuing to explore and reveal. For the purpose of this essay, a simplified overview of neuroplastic change is shown in figure 1.

Figure 1 A simplified overview of neuroplastic change



In this overview, each person's ongoing life experiences involve physical interactions with the world, social interactions with others, and the cognitive processing of these interactions. The physical interaction involves input received through the various senses of sight, hearing, touch, smell and taste, as well as physical activities such as eating, walking, operating equipment, speaking, and writing. Social interaction involves day-to-day relationships with others in the community, in educational institutions and in workplaces. The cognitive processing of physical and social interactions includes perception, interpretation, memorising, critical thinking, reflection, meditation, recall, association, judgment, analysis, deduction, decision-making and hand-eye coordination.

Neuroplasticity is now seen to be central to our processes of learning. Learning new skills and knowledge actually involves ongoing physical and biological changes within the brain. It is important therefore that individuals, educators, trainers, managers and supervisors in innovative workplaces have a shared basic understanding of neuroplasticity and know how to take suitable action to help people to control it.

We have learned that neuroplasticity is not only possible but that it is constantly in action. That is the way we adapt to changing conditions, the way we learn new facts and the way we develop new skills ... We must therefore understand neuroplasticity and learn how to control it. (Begley 2008, p.244)

The nature of intelligence—multiple intelligences

Another area of important development within the cognitive sciences is the work of Gardner et al. on multiple intelligences (Armstrong 2009; Gardner 1999, 2006; Smith 2008). The theory of multiple intelligences was originally proposed in 1983 by Dr Howard Gardner, Professor of Education at Harvard University. It suggests that the traditional notion of intelligence is much too limited. Gardner proposed eight different intelligences to account for a wider range of human cognitive capability. A useful way of categorising the various aspects of the day-to-day experiences that influence the ongoing evolution and change within each person's brain (that is, *lifelong learning*) is to examine them in the context of the identified multiple intelligences as shown in table 3.

Table 3 Aspects of experience linked to multiple intelligences

Aspects of experience	Description	Related form of intelligence
Language aspects	Experiences involving the <i>use of words</i> , for example, writing, reading, listening, communicating interactively either face to face or with the aid of technology etc.	Linguistic intelligence
Reasoning and numerical aspects	Experiences involving <i>logical reasoning and mathematics</i> , for example, recognising and solving problems, troubleshooting, evaluating and analysing issues and interpreting and manipulating numerical information including estimation and calculation etc.	Logical–mathematical intelligence
Visual/spatial aspects	Experiences involving <i>visual images and spatial judgments</i> , for example, observing and interpreting scenes, pictures, diagrams, figures, colour, tone, hue etc. and judging, estimating and measuring distance, height, depth, weight, volume, shape, orientation, perspective etc.	Spatial intelligence
Music and sound aspects	Experiences involving <i>sounds and music</i> , for example, being conscious of qualities of sounds such as pitch, loudness, melody, harmony, timbre, beat (this could involve a musical instrument, a band or orchestra, singing solo or in a group, or even an awareness of the throb or whine of an engine, a vehicle or a piece of plant) etc.	Musical intelligence
Body aspects	Experiences involving the <i>physical aspects</i> of the human body, for example, lifting, throwing, running, kicking, operating (tools, plant or a piece of equipment), steering, adjusting, seeing, hearing and listening, feeling, tasting, smelling, applying eye-hand coordination etc.	Kinesthetic intelligence
People aspects	Experiences involving <i>social interaction and social relationships</i> , for example, building and maintaining relationships with others, networking, resolving conflicts, comforting, consoling, helping, supporting and encouraging others, showing empathy, expressing sympathy etc.	Interpersonal intelligence¹
Self aspects	Experiences involving <i>self-reflection</i> , for example, reflecting on past experiences (including achievements, negative outcomes, opportunities for improvement etc.), meditating, managing stress, developing commitment and enthusiasm, developing and adhering to personal values, attitudes, and ethics, etc.	Intrapersonal intelligence¹
Natural aspects	Experiences involving the observation of the way we relate to the <i>natural world</i> , for example, being conscious of the world around us (including fauna, flora and the ecology), practising sustainability, minimising pollution, avoiding waste, encouraging environmental protection and conservation, acting on climate change, 'minimising our environmental footprint' etc.	Naturalist intelligence

Note 1. Interpersonal and intrapersonal intelligences are also seen as components of emotional Intelligence (Abraham 2005; Elias, Kress & Hunter 2008; Schulze et al. 2005).

The researchers exploring the theory of multiple intelligences, as well as the neuroscientists extending our understanding of neuroplasticity, all point to the value and benefits for learning, brain development and mental wellbeing of engaging life experiences that span, as far as possible, all of the bodily senses and involve all of the physical, cognitive and social dimensions. While the exact nature and context of the experiences inevitably varies from one individual to another and between the contexts in which they live and work, the experiences will usually contain a mix of some if not all of the aspects summarised in the table. Given the findings of research in the areas of

neuroplasticity and multiple intelligences, it is beneficial for experiences to incorporate as many of the listed aspects as possible.

Many of the authors reporting on the various opportunities presented by neuroplasticity (brain development and associated learning) have drawn attention to the need for a number of important conditions to be fulfilled for desired neuroplastic changes to occur in response to experiences (learning). Firstly, the person concerned must be aware of and pay close attention to the experiences. Secondly, the experiences should have some degree of challenge and novelty. Thirdly, the person concerned should diligently engage with the experiences, that is, have a conscious awareness, focus and participation. Fourthly, thinking is just as important as doing, for example, interpretation, analysis, reflection, mental rehearsing and meditation. Fifth, there needs to be substantial practice, repetition and reinforcement. Sixth, the person needs to be emotionally aroused by the experiences. This could be positive arousal as in rewarding and satisfying experiences or negative arousal as in situations involving fear and threat. Sixth, involvement in the experience must be active and passionate (not passive), requiring focus, effort, commitment and persistence. Seventh, the person concerned should have a positive attitude, commitment and enthusiasm for the activities involved in the experiences (and their outcomes).

The OECD quote given earlier (2010, p.57) draws attention to the way in which learning at work and learning in all sectors of education form part of a lifelong process that contributes to and *helps shape innovation outcomes*. This comment resonates with the findings of the researchers probing the emerging new insights into how our brains grow and evolve. This focus on an ongoing *lifelong process* of learning from all areas of personal experience (including work and formal education) is echoed in the conclusions of Michael Meredich and Rob de Charms, as summarised by Schwartz and Begley:

Experience coupled with attention leads to physical changes in the structure and future functioning of the nervous system. This leads us with a clear physiological fact ... moment by moment we choose and sculpt how our ever-changing minds will work, we choose who we will be in the next moment in a very real sense, and these choices are left embossed in physical form on our material selves. (Schwartz & Begley 2002, p.339)

Implications of these developments

What are the implications of these developments for learning?

The research on brain growth confirms that learning (that is, neuroplastic change within the brain) is a twenty-four-hours-seven-days-a-week (24-7) activity. It does not just occur when we are in an education institution or a training facility. Our brain is undergoing continuous change and evolution and is being constantly shaped by our physical interaction with the world, our social relationships and dealings with others and the very processes of thinking. This view of learning is summarised in the diagram in figure 2. It is derived from a model proposed by Rumsey (2001, pp.43, 162).

As described earlier, the ways in which individuals learn are enhanced when they have the required disposition and attitudes and have a basic understanding of how their brain develops and grows and what they can do to enhance the learning process. Examples of critical dispositional elements are shown in table 6.

Figure 2 Ways of learning

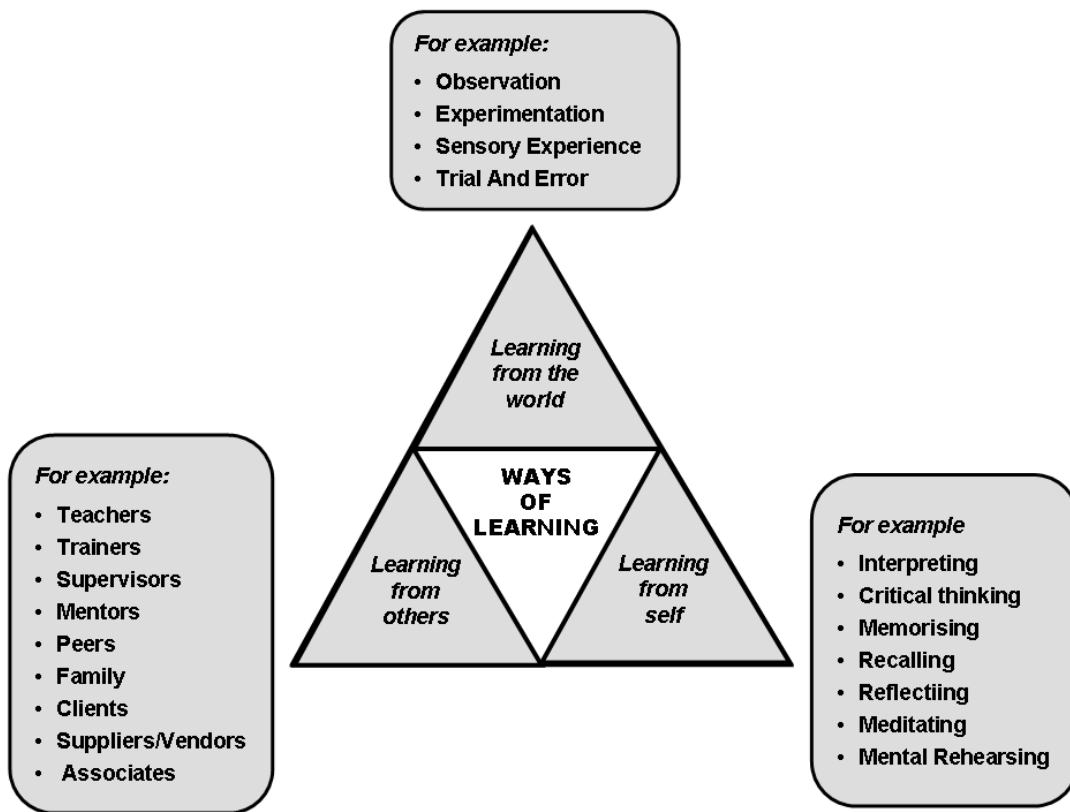


Table 4 Examples of critical dispositional and attitudinal requirements for effective learning

<ul style="list-style-type: none"> ◇ Being <i>actively engaged</i> with the learning activity or experience ◇ Being <i>attentive</i> and remaining <i>focused</i> on the learning activity or experience ◇ Avoiding and controlling <i>distractions</i>—consciously trying to keep focused ◇ Having a <i>positive</i> and <i>optimistic</i> attitude 	<ul style="list-style-type: none"> ◇ Developing and maintaining a <i>will</i> to learn and grow ◇ Being <i>motivated</i> to learn from the experience ◇ Having a <i>commitment</i> to the learning activities ◇ Developing and maintaining an <i>interest</i> in what is being learned
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There are a number of ways in which learners can exploit the neuroplastic nature of their brains to enhance their learning processes. They should regularly explore new directions, opportunities, experiences and interests. They should accept challenges and persevere in their learning activities, reaching out and having a go. They should appreciate the importance of repetition and reinforcement, persistently addressing tasks until completed, practising them and mentally rehearsing them. They need to attend carefully to their day-to-day activities, consciously focusing on their daily experiences and environments. They should consistently reflect on their various activities and what is happening around them, asking themselves: *What? Why? When? Who? What are the causes and effects? What if ...?* They need to ponder opportunities for change and how things could be done better. They should practise being curious—questioning and discovering. They should endeavour to be actively involved with others in the wider learning processes (with educators, peers, supervisors, clients etc.). They should endeavour to remain positive, enthusiastic and committed.

Learners should practise thinking laterally and be prepared to take initiatives and be innovative. They need to actively engage their own experiences, during education and training courses, at work, within their home and during community activities. They should observe and pay attention to their

surroundings as much as possible, consciously scanning, monitoring and critically studying what is going on around them. Finally, they need to be aware and conscious of their sensory inputs.

What do the various developments mean for workers?

The emerging findings on neuroplasticity and multiple intelligences offer workers the potential to be more aware of how they can enhance their own learning. It is now recognised that people's brains can continue to change, grow and evolve in response to day-to-day experiences until the day they die. If these changes can be suitably controlled and managed, it will become possible to extend a person's effective cognitive lifespan, thereby also enabling them to pursue longer and more productive working lives. To achieve this, workers would require more flexibility in job roles and the opportunity for periodic job rotation, which would open up opportunities for addressing new challenges and novel situations. As summarised earlier, these are important conditions if individuals are going to learn from their workplace experiences. This supports and is consistent with the principles of adult education and continuous lifelong learning.

The following lists an additional set of cognitive skills beyond those summarised in table 1 that are likely to be required by workers in innovative workplaces. Of course, the sets of skills needed will depend on the innovative workplace context.

- ✧ thinking about learning and learning about thinking, including a basic understanding of neuroplasticity and how to control it
- ✧ seeking and being actively involved in lifetime experiences (as far as possible, experiences which exercise all of the senses and involve physical, cognitive and social activities)
- ✧ attending and focusing (that is, paying attention to experiences)
- ✧ being aware and conscious of what is happening in the course of experiences
- ✧ meditating and reflecting on possibilities, opportunities, past experiences and actions
- ✧ mentally rehearsing an activity.

The literature on neuroplasticity, innovation and creativity emphasises the importance of having appropriate dispositions, attitudes and motivation to enable effective learning from day-to-day experiences. Table 5 summarises examples of desirable dispositional, attitudinal and motivational requirements for effective learning to occur.

Table 5 Desirable dispositional and attitudinal requirements for effective learning

✧ Maintaining interest	✧ Having commitment and perseverance	✧ Showing initiative
✧ Having a passion for a goal or activity	✧ Being ambitious	✧ Demonstrating enthusiasm
✧ Being confident	✧ Showing empathy for others	✧ Demonstrating drive and determination
✧ Displaying curiosity	✧ Being responsible and aware of duty of care	✧ Taking and sharing responsibility
✧ Being positive and optimistic		

Given the required conditions for effective learning and associated neuroplastic brain developments included in the research findings described earlier in this essay, there are a number of suggested additional requirements within the workplace and associated educational and training environments which will enhance the effectiveness of the learning processes:

- ✧ Workers need to be able to *engage* with and have *access* to appropriate learning in both work and educational settings.
- ✧ Workers need to be suitably *encouraged* and *supported* by others in both the workplace and associated educational and training institutions. This will often include demonstration,

interaction and guidance during learning experiences to assist workers to build and consolidate their skills and knowledge.

- ✧ Experiences need to involve some degree of *challenge*.
- ✧ Experiences need to include elements of *novelty*.
- ✧ Workers should seek *feedback* on their performance. Positive feedback and praise from others for successful achievements reinforce the learning involved, while feedback on errors and poor performance can provide opportunities for rectification and relearning.
- ✧ There need to be opportunities for workers to *practise* skills being learnt, with appropriate degrees of guidance from experts.
- ✧ Suitable *resources* need to be available to assist the learning processes for workers. These may be workplace resources such as organisational objectives, standard operating procedures, safety and security management plans, equipment and systems manuals, risk management strategies and quality and customer service standards. In the education and training environment, they may include training curriculum, workbooks, tests, assignments, project specifications, reference materials, case studies, audiovisual materials and online resources.

The central implication for learners is the confirmation of the importance of learning to learn—developing a better basic understanding of how their brains evolve and grow and what actions they can take as individuals to control and shape these changes. This includes knowing how to think and learn, and consciously using this knowledge to exercise cognitive processes and to extend the brain in ways that will improve their productivity and enjoyment of life and extend their own effective cognitive lifespan, including avoidance or deferral of the onset of premature mental decline and dementia (Valenzuela 2009; Wirth & Perkins 2007).

For older workers, the new insights into how the brain grows and evolves provide a range of opportunities and benefits:

- ✧ potential extension of the working life by bringing workers' mental wellbeing into better synchronism with physical wellbeing
- ✧ increased and longer-term remuneration flowing from an extended effective working life
- ✧ improved work satisfaction and sense of achievement through the development and application of more relevant skills within a supportive workplace culture
- ✧ a feeling of making a contribution to innovation, industrial development and workplace operations.

Arguably, the most significant implication for older workers is that:
It's never too late to learn or relearn.

Implications for supervisors and managers in innovative workplaces

What do these developments mean for supervisors and managers in innovative workplaces? The following are a series of suggestions organised under the headings of personal and professional development, work organisation, workplace culture and workforce management. In presenting these suggestions, the author notes that the organisation of work in industry settings by supervisors and managers must also meet a range of other obligations beyond the personal and professional development and stimulation of workers.

Personal and professional development

It is important that organisations provide ongoing opportunities for learning experiences (in institutions, in workplace training and through structured experiences in the workplace) that embody the principles and conditions for the desirable neuroplastic change and learning that have been identified by researchers in the areas of neuroscience and cognition. Of course, such learning experiences need to be modulated by the local contexts of the innovative workplaces concerned and should relate flexibly to the emerging and evolving ambitions and interests of the individuals concerned.

Professional development also needs to include the synergistic team learning that occurs when a work group is cooperatively committed to achieving collective innovative outcomes and results. This should include opportunities to discuss shared pictures of the future, whereby collective initiative, contribution, commitment and engagement rather than mere compliance and conformity are fostered. Professional development includes group-learning activities involving intense high-quality networking and exchange of ideas and listening. These activities should also include a sharing of experiences with a creative exploration of subtle issues, deep listening to one another and suspension of one's own views.

Workforce management

In this area the focus should be on maintaining the right mix of skills needed for the organisation to pursue and achieve its innovation objectives. This includes:

- ✧ recruiting personnel with relevant initial skills sets
- ✧ providing ongoing personal training and professional development activities for existing personnel (as described above)
- ✧ retaining personnel who are able to continue contributing to organisational activities and objectives and who demonstrate both valuable existing capabilities and a commitment and ability to learn from ongoing experiences at work and education. Given the findings on neuroplasticity, organisations can assist their existing personnel to effectively *extend their working lives* by providing them with structured workplace and educational experiences. In this regard, it is valuable to see life as a series of transitions, of which retirement is but one example. It is suggested that retirement should not be regarded as the end of a working career but rather as a transition to new opportunities.

Work organisation should include job rotation arrangements to enable workers to progress periodically to different work roles that present new experiential challenges and opportunities. The rotational arrangements should be designed to enable workers to learn the cognitive skills and knowledge that will enable them to contribute individually and collectively to the achievement of the organisation's innovation objectives.

Work organisation also needs to include appropriate progression plans for mature-age workers; these plans should enable them to continue to play active roles in innovation and organisational activities of benefit to the organisation for as long as they desire and as long as they are physically and mentally able. In this context arrangements that enable workers to participate in work activities beyond the traditional retirement age should be included. Examples of arrangements that could be incorporated into such plans (dependent on the organisational context and the individual's capabilities) are provided in table 6.

Table 6 Examples of job roles and work activities for mature-age workers

✧ Special projects	✧ Research roles	✧ Formal and informal training functions
✧ Internal and external consulting	✧ Sales and marketing roles	✧ Liaison and lobbying functions
✧ Business development functions	✧ Advisory roles	✧ Risk management roles
	✧ Troubleshooting duties	

The *workplace culture* of the organisation should be encouraging and supportive, with an acknowledgment that everyone has the potential to contribute—individually and collectively—to the organisation’s innovation goals, regardless of age. The culture should reflect an understanding that workers have the potential to grow and learn from their work and educational experiences and can make an ongoing contribution providing: they are given the right level of support from the organisation and their managers, supervisors, trainers and peers; they have a basic understanding of how they are able to learn and how their brain grows and evolves; and they are encouraged to develop and maintain the enthusiasm, motivation, commitment and focus needed to benefit from ongoing workplace and educational learning experiences.

Supervisors, team leaders and mentors in the workplace therefore need to promote a workplace culture that is supportive and encouraging for workers, one which enables personal growth and professional development. Priority needs to be given to providing stimulating and challenging work. Action should be taken to identify work arrangements that involve boring and overly repetitive work and these should be reorganised to be more challenging and interesting. Supervisors and team leaders need to ensure that workers continue to have rich work and educational experiences and that they provide guidance, encouragement and support, not just in gaining technical skills and factual and procedural knowledge, but also thinking skills and knowledge. They need to optimise workplace organisation, including job rotation, ensuring the availability of project work and the potential for extending the working lives of employees beyond traditional retirement.

The workplace culture needs to be that of a *learning organisation*. Marquardt (1997) suggests that there are six important types of skills that need to be systematically developed within learning organisations:

- ✧ systems thinking
- ✧ mental models (how people understand and interpret the world and take appropriate action)
- ✧ personal mastery (cognitive, metacognitive, psychomotor and dispositional skills and knowledge achieved through initial training and ongoing personal and professional development)
- ✧ team learning (through collective professional development and work experiences)
- ✧ a shared vision within the organisation
- ✧ an ongoing dialogue between managers, supervisory personnel and peers.

Implications for teachers and trainers

The key implication for vocational teachers and trainers is that they need to empower students to learn effectively from their day-to-day experiences in educational, workplace and community settings. This will involve inculcating in students a basic understanding and awareness of how learning takes place and how their brains continue to evolve throughout their lifetimes; they will also need to understand the actions they can take to enhance their own brain development and learning processes, improve their mental wellbeing and potentially extend their own effective working lives. This does not preclude the role of teachers and trainers in helping learners to develop the required factual and procedural knowledge, the prescribed cognitive and psychomotor skills and the disposition and attitudes essential for effective learning.

In particular, in the course of their training function, vocational teachers and trainers need to be aware of the benefits of exposing students to experiences that span multiple intelligences and include a focus on thinking about learning and learning about thinking. Teachers and trainers should endeavour as much as possible to organise and provide opportunities for rich learning that covers the full range of multiple intelligences and involves cognitive, physical and social dimensions. They also need to promote the importance of an active physical, mental and social life to enable a long, productive, satisfying and enjoyable lifespan. This includes drawing students' attention to the value of exercising and caring for not only their bodies but also their minds.

Some practical examples

The following are three examples from industry that demonstrate how these various developments in cognition and neuroplasticity could be applied in practical innovative workplace situations. While the examples are hypothetical, they are based on actual case studies. In considering these practical case studies, it is worth reiterating that the skills sets required in effective workplace and learning environments encompass not only critical cognitive skills and knowledge but also appropriate *personal dispositions, attitudes and motivation*.

Practical example 1: an innovative ICT company

The ICT company is an innovative service provider specialising in the provision of unique systems solutions to organisations to enable them to integrate their computing infrastructure, internet and intranet systems, communication systems and information security requirements. The organisation specialises in cloud system technology and video-conferencing to achieve cost efficiencies, operational flexibility and inter-connectiveness.

The service provider regards its staff as the spearhead of its innovative capabilities, encouraging all personnel to work collaboratively—sharing ideas and providing ongoing informal guidance and assistance to each other. The CEO is a committed networker with vendors and other ICT companies and associations and promotes the concept of active networking to his personnel. The company has six major sections—sales and marketing, finance and administration, planning and product development, engineering, the national operations centre (NOC) and customer service. There is a deliberate policy of gradually rotating personnel across the various sections. In some instances, this is to enable personnel to gain experience and insight into the role and functions of the other sections, as well as to build relationships with the staff in those sections. In other instances, it forms part of career progression within the company. The company has periodic staff meetings in which personnel are encouraged to reflect on the company's achievements and its opportunities and to share ideas on innovations and initiatives in products and systems that would benefit existing and potential customers. The company contracts mature-age, expert former employees to assist as business advisors, market researchers and professional development consultants.

Practical example 2: An innovative paper manufacturing company

The innovative manufacturing company uses the latest automated manufacturing technologies to produce paper products. It is vertically integrated with state-of-the-art monitoring and control systems designed to increase the precision and responsiveness of quality assurance and allow rapid response to product change requirements, while ensuring optimisation of efficiency and minimisation of production downtime. The vertical integration extends from logging, right through production, to the distribution of final products. The overall production and delivery process is observed and controlled through a central control room, where operators and technicians monitor and adjust every aspect of the production process. Using high-precision information and computing technologies integrated with the high-performance workforce, the company has the capability to

quickly produce a diverse range of high-quality paper products to meet customer needs in small or large volumes with the flexibility of custom manufacturing and the efficiency of mass production.

The company has an intensive training system for its staff with a focus on adaptation, problem-solving, quality assurance, teamwork, communication and learning from experience. In the course of their careers, personnel gradually develop the skills sets required for working in the various production areas of primary resource processing, pulping, reprocessing of waste paper, chemical recovery, wet-end operations, dry-end operations, coating, finishing and converting, water processing and power and steam generation. Emphasis has been placed on using the full range of sensory inputs to monitor and evaluate the status of production operations and to troubleshoot identified problems. For example, an operator would gauge the status of pulping operations through sight (on control monitors and direct viewing of the product and the process), smell, sound (changes in pitch and intensity of the whine of the equipment), temperature and vibrations. The company actively promotes the concept of lifelong learning, with some guidance to staff on the benefits of learning both on the job as well as in organised, structured formal training. A local TAFE college has an ongoing association with the company, working with company trainers and mentors. Senior personnel who have achieved a wide range and depth of experience play active roles in both the troubleshooting of problems and the planning of the ongoing innovative development of the production facility. Highly experienced retired personnel are usually retained by the company in both advisory and training capacities.

Practical example 3: an innovative logistics freight-forwarding company

This logistics freight-forwarding organisation is part of a vertically integrated global company that provides integrated logistics and freight-forwarding services both in Australia and across the world. Using innovative systems and ICT technology, strategic workplace structures and a mentored professional development scheme, the organisation is able to provide highly efficient logistics services that transport, store and distribute a wide range of special freight² rapidly to any location in the world. The organisation takes great pride in its ability to anticipate and manage any contingencies that may arise in the course of a logistics project—from natural disasters, wars and political conflicts, to industrial disputes and equipment failures. It also specialises in managing and facilitating special major logistics projects such as industry exhibitions, major sporting events (such as the Olympics Games or F1 Motor Racing), or the transport of materials and equipment needed for the establishment of an industrial complex or mine in a remote location.

The organisation is proud of its outstanding record for customer service and the quality and global competitiveness of its logistics and freight-forwarding services. This is achieved through its focus on the innovative use of systems technologies across the whole supply chain and its commitment to ensuring that its staff are highly skilled, adaptive, innovative and resourceful with an ongoing commitment to learning both from experience and from formal training opportunities provided by the company.

In the course of their careers, personnel gradually develop the skills sets to work across a wide range of sections of the integrated logistics supply chain, including transport and distribution, storage and warehousing, domestic and international freight forwarding, the management of the import, export and transiting of goods, customs-broking services and the tracing, tracking and troubleshooting of cargo, from its point of origin, to its delivery destination. The organisation sees its strength as building a workforce of highly experienced adaptive personnel with an in-depth understanding of the whole supply chain and the systems technologies used to facilitate the logistics and freight-forwarding services provided. The organisation has a culture of valuing the accumulated skills, knowledge and experience of its staff and uses the expertise of its senior staff and retired

² Special freight includes goods that are refrigerated, fragile etc.

personnel in both the development of the organisation's services and systems, as well as in the professional development of new and existing staff.

Conclusion

The emerging findings on neuroplasticity and multiple intelligences have significant implications for how people learn and what action they can take in association with others in their workplace and educational settings to enhance the development of the skills sets needed to participate in workplaces generally, and innovative workplaces in particular. This awareness not only opens up the opportunities for improved and more relevant skills and knowledge but also has the potential to extend people's effective cognitive lifespans and, indirectly, their working and community lives.

Some of the more significant of the findings include the importance for learning and brain growth of the exposure of people to the ongoing rich experiences in their community, work and educational environments which involve the close attention and focus of the people concerned, the engagement of a wide spectrum of bodily senses, a degree of novelty and challenge and an interaction and involvement with others. The findings also indicate the need for a broader concept of skills sets which incorporates not only skills and knowledge but also appropriate personal dispositions, attitudes and motivation.

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Why firms innovate and what it means for VET

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In this chapter we explore what innovative activity is occurring in the financial services, retail and wholesale and biotechnology areas of Australian firms. We also investigate how firms go about ensuring they have the skills and knowledge to be innovative. In doing so we comment on the importance of background and experience in a particular field or discipline, and what this all means for training in vocational education and training. We argue that, although firms have introduced different products, processes, and technologies to varying degrees, it would be a mistake to believe that they are constantly preoccupied with the need to be innovative. Instead, firms have adapted to advances in information and telecommunications technologies, and innovative activity for most firms has been more incremental than revolutionary in its nature and impact.

Introduction

This chapter is based on insights gained from interviews carried out with managers and supervisors in 30 Australian firms across three different states. These interviews provided us with information on the workplace experience of firms in the sectors reviewed and their skills requirements to support innovation now and into the future. These interviews were undertaken as part of a project for the Department of Education, Training and Workplace Relations (DEEWR).

We agree with Peter Drucker (2002), who makes the point that there are some innovations that come from brilliant ideas but the real source of successful innovations is a result of 'the conscious search for innovation opportunities, which are found only in a few situations. Four such areas of opportunity exist within a company or industry: unexpected occurrences, incongruities, process needs, and industry and market changes' (p.96). From our research we find, as Drucker suggests, it is from these four areas of opportunity that innovation flows.

What we mean by innovation

It makes little sense to think of innovation solely as something or some activity that is new or which has not been observed or tried before. If we were to follow this line of thinking to innovation in firms, then we would certainly be hard pressed to find many things that are completely new. It is more fruitful to think of innovation as something or some activity that is either new to the firm itself, or expands or enhances some traditional product, application or practice. Kearney (2007) is of the view that we also need to think of innovation as something that is useful and adds value, while Drucker warns us about focusing too much on creativity and the generation of new ideas. He says:

Above all, innovation is work rather than genius ... There are clearly people who are more talented innovators than others, but their talents lie in well-defined areas ... In innovation as in any other endeavour, there is talent, there is ingenuity and there is knowledge. But when all is said and done, what innovation requires is hard, focussed, purposeful work. If diligence, persistence, and commitment are lacking, talent, ingenuity and knowledge are of no avail.

(Drucker 2003, p.102)

Another way to explain what is meant by innovation is to look at how the Australian Government protects the intellectual property of discoveries through the granting of standard and innovation patents. These patents aim to provide protection for new, inventive and useful devices, substances, methods or processes. Where standard patents are granted for a period of 20 years, innovation patents are for a period of just eight years. The innovation patent was introduced in 2001 to stimulate innovation among small-to-medium business and local industry and is used to protect inventions with a short market life that might be superseded by newer innovations (such as computer software).

The Australian Bureau of Statistics (ABS 2005) takes innovation to be 'the development, introduction or implementation of significantly improved goods, services or processes'. This means any new or significantly improved:

- ✧ good or service or combination of these which is new to a business and its characteristics or intended uses differ significantly from those previously produced
- ✧ operational process—a significant change for a business in its methods of producing or delivering goods or services
- ✧ organisational/managerial process—a significant change to the strategies, structures or routines of a business which aim to improve performance.

In this essay we explore the innovative activity occurring in Australian firms, concentrating on firms in the financial services, retail, and wholesale and biotechnology areas. We also explore how they go about ensuring they have the skills and knowledge to be innovative, and in doing so comment on the importance of background and experience in a particular field or discipline and what these mean for training in vocational education and training.

We will argue that, although firms have to varying degrees introduced different or new products, processes and technologies, it would be a mistake to believe that their day-to-day activities are consumed by the need to be innovative. It is true that across industries there is a rhetoric that underscores the need for innovation, but we have found that, apart from adapting many advances in information and telecommunications technologies (ICT), innovative activity for most firms has been more incremental than revolutionary in its nature and impact. That said, it is not unusual for large financial institutions (and even government departments) to have in place departments whose major activities occur under the name of innovation and change. It seems that the major component of this activity is the analysis of customer feedback and behaviours and the ongoing search for new market opportunities. In this, the adaptation of advanced ICT technologies to provide solutions is common.

Our investigation finds that the key triggers of occurrences of innovation in Australian firms include the availability of new or improved technologies, regulatory change, deficiencies in resources or current workplace practice, economic realities, and consumer demand. This is not to deny the stimulus for change that is created by intelligent people coming up with a good idea or for different ways of working.

Adopting new or improved technologies

Whatever caveats we might apply to the real meaning of innovation, we cannot ignore the fact that over the last two or three decades there have been significant advances in science, information, telecommunications and design technology. These have resulted in immense benefits for firms in old and new industries, and for individuals. Manual and mechanical operations have been automated by increasingly more powerful computers and systems which have accelerated the speed with which goods, services and information are designed, produced, warehoused or stored, distributed, and accessed. Expansion of the internet has provided online spaces for trade to be conducted, communications to be exchanged, people to meet, games to be played and work to be allocated and done. Scanning and imaging technologies have revolutionised the sharing of information, as well as the tracking of stock and the security of venues. The applications of this to the distribution of goods (especially in the retail industry) is reflected in the increased uptake of the 'just-in-time' and 'just enough' concepts of warehousing and distribution. The application of this technology in the financial services industry is reflected in the scanning of signatures required for contracts and the scanning of the contracts themselves, thus avoiding their having to be written in duplicate or triplicate. Scientific discoveries, which have also been fuelled by more powerful technology, have introduced new and improved materials, drugs, medications and medical equipment—also improving the ways in which medications are delivered (including the application of patches, or sprays to the skin to medicate different ailments). Across all inventions there is the need for someone to have a good idea in the first place.

These ICT developments have been picked up in varying ways and to different degrees by firms in the financial, retail, wholesale and biotechnology industries. The larger, the firm and the more complex the nature of its work and organisation, the more attention is paid to ensuring that best use is made of the latest IT applications. Of course, the introduction of technological equipment and software is especially dependent on the availability of funds and the relevance of the application to the business of the firm.

Most firms have an online presence or are looking to create one. These are used as interactive sites as well as for marketing and advertising goods and services. Larger firms tend to have more sophisticated websites. These online applications enable customers in Australia and overseas to visit company websites to access information, place queries, order goods and pay for purchases. Online business transactions are commonplace, while electronic records are gradually taking the place of paper records. New databases are replacing what have in some industries (especially the financial services industry) been called 'legacy' systems. These are repositories of data that document the history of transactions. Such systems are also gradually being redeveloped. Interfaces between IT systems in different sites (both within and external to the organisation) enable the direct exchange of data between sites, as well as with government departments; for example, direct exchange of income data for taxation purposes, which enables accountants to collect information from customers and give them access to up-to-date information. The benefits derived are improved efficiency and consistency of decision-making.

In call and administration centres (also regularly used by the financial services industry) work is allocated electronically, responses are timed and monitored for timeliness and quality assurance, and responses can be provided by people administering processes from different state and international locations. Although companies may apply some administrative restrictions and protocols, it is now possible for employees to work remotely from home.

Online training applications are often used by firms to ensure that their employees become and remain compliant with regulatory requirements. They are also used to contain costs and to enable staff to complete modules at their own pace.

In the banking and insurance sectors firms have now made it possible for corporate and individual customers to manage and monitor their accounts online. These online applications have both helped firms to contain costs by reducing the number of tellers required and attempted to make transactions and records more transparent and immediately accessible to customers. Such online interactive applications for formerly face-to-face transactions have had some unanticipated consequences. They have brought comfort to some consumers who like the flexibility of managing their own accounts and in their own time but they have been less accepted by customers who at times favour a more personalised approach, or who are still hesitant about the online security of their personal and financial details, or who are overwhelmed by interacting with computerised systems. This has led one financial institution to bring back the concept of local bank managers, and another to establish service hubs.

In developing countries the widespread uptake of mobile phone technologies has opened up opportunities for financial institutions in Australia to extend their reach to previously non-banking or under-banking populations to engage in banking-type activities (for example, transferring funds to third parties, namely relatives) at minimal cost to the firm.

Technological advances also bring with them consequences, such as the need for the continual upgrade of systems and equipment. Where financial institutions and large retail firms will require fairly sophisticated client-management systems, scanning technology, and processes to manage document and data storage and retrieval and the latest versions of certain software packages, smaller firms across industry sectors may not invest too substantially in the latest IT software, particularly for regular administrative processes.

Remaining compliant with government regulations and industry codes of practice

A key trigger for innovation in the financial, retail and wholesale services, and biotechnology sectors is regulatory change and the need for businesses to remain compliant with these changes. Another influence is the application of industry codes of practice. These changes can sometimes interfere with the free flow of business responses, and at other times can facilitate them. In the biotechnology industry, implementation of the *Therapeutic Goods Administration (TGA)* legislation requires drug companies wishing to undertake testing and trialling of drugs to acquire TGA accreditation and to satisfy ethics approval requirements. This TGA accreditation, based on rigorous quality assurance audits, means that accredited companies or those companies working in partnership with them, do not have to undergo another ethics approval process before they can undertake research trials. Having the TGA accreditation has created a niche market for companies servicing pharmaceutical drug trials. It means they can provide services for Phase 1¹ trials for international and domestic companies, who can then begin their trials almost immediately. This ability to provide accredited service means that regulation has actually enhanced rather than hampered the ability of TGA-accredited companies to service customers. It has given Australian providers some advantages in the provision of their services vis-a-vis international providers, where the process of granting approvals from drug regulation authorities is longer, meaning that the research also takes longer.

The use of licences, accreditations, and registrations as forms of admission to regulated occupations and quality control and assurance are not new and we have many professional and trade occupations that must meet specific registration or licensing requirements before they can practise their profession or trade (for example, medical doctors, lawyers, teachers in primary and secondary schools, electricians, gas fitters, builders and so on). What is new is the extension of this regulation to other occupations. Today, individuals and organisations wanting to provide advice about

¹ Phase 1 trials are the first time a drug is tested in a human population.

financial services (including life insurance, superannuation, income protection, trauma protection, mortgages, loans and credit and so on) need to be licensed under the *Financial Services Industry Reform* legislation. Banking codes of practice have also influenced how banks interact with their customers, including their being more transparent about fees and charges. These changes have placed added imposts on those working in the financial services industry to undergo training to complete their accreditation and continued professional development to maintain their accreditation. For banks the need for transparency has meant an increased focus on clear documentation.

Legislation covering occupational health and safety (OHS), trading hours and environmental issues also affects companies in financial, and retail and wholesale industries. Online applications have made it possible for individuals whose work permits to work remotely from home. As companies realise that there are occupational health and safety regulations that might impinge on this, they want to be reassured of the ergonomic suitability of home office equipment and the safety of home environments. The need for environmental sustainability is reflected in company attempts to reduce the wastage of paper, power and fuel, and the building of environmentally friendly work spaces.

Intellectual property issues are especially of concern to companies which design, manufacture and distribute or retail their products in world markets, in that they are keen to prevent the markets being flooded with cheap copies of their products. In one instance company lawyers have developed a close relationship with the customs department to ensure legislation which allows customs to intercept and inspect containers of imported goods to prevent the entry of counterfeit and cheap copies of their products.

Economic realities

The need to make strategic adjustments in processes and infrastructure to attain business needs is a powerful motivator of innovation and changing work processes and practices and takes into account changes in economic markets emanating from domestic and international competition. Adjustments to the business process also need to factor in the need to contain costs while maintaining viability and increasing profitability. Another powerful motivator interlinked with revenue growth and profitability is the need to meet customer demands and nurture their customer loyalty and attachment.

International and domestic competition

Over the last three decades the opening-up of economic borders as well as country borders (for example, China and Europe, respectively) and the implementation of free trade agreements have increased the mobility of labour and capital. Not all movement of labour comprises highly skilled workers, although more of them are likely to be working for international corporations. In the growing industrialising cities of China and India unskilled workers are also on the move as they leave their rural areas for jobs in the cities. At the same time manufacturing and service industries in advanced economies have shifted operations offshore to take advantage of the low-wage structures of developing countries. This global competition for the production and distribution of goods and services is especially quoted by firms with international reach as a fundamental reason prompting them to engage in continuous improvement. One Australian clothing and sports equipment retailer and wholesaler has even implemented training for offshore third-party retailers to ensure the smooth functioning of operations and distribution networks.

In the retail and wholesale services industry the pressure from competitors is seen in the increased power of large monopolies such as supermarket retail chains to establish direct relationships with growers and producers to source their products. In doing so they are bypassing wholesalers who have traditionally acted as intermediaries between retailers and producers, manufacturers and growers. The need to carve out a place for themselves as a consequence of being squeezed out of

traditional markets is another trigger for changing the way that companies across different parts of the retail and wholesale sectors operate. They are increasingly feeling the pressure to seek out niche or specialised markets.

In the financial services industry the relaxation of traditional safeguards in financial markets and the movement of capital and equity across the globe have intertwined the fortunes of world economies. But this has also meant that economic shocks felt in one country or region are likely to be experienced by trading partners in other countries, for example, the after-shocks of collapses of major financial institutions in the United States and Europe are felt in other world economies. Firms we have spoken to in Australia have also been affected to some extent, and international companies have had to restructure their functions to adapt to changed conditions. At the same time the activities of unscrupulous businesses on the domestic scene have also seen consumers fall prey to wealth-creation schemes that have not always been successful. These occurrences have provoked a stricter regulatory environment, with the Australian Government enacting legislation to protect the finances and other property of consumers. The *Financial Services Industry Reform* legislation (FSIR) is a case in point.

Cost-containment and efficiencies

The reality for most firms, large or small, regardless of industry sector, is the need to keep labour costs down as well as being more cost-efficient, and it is these requirements that largely prompt innovative or creative activities. Cost-containment of the more traditional ways of working, including processing, storing and retrieving records, administering claims and transactions, and making statistical projections, is a key consideration in company decisions to purchase more, and up-to-date, electronic technology and equipment and software applications or to invest in their in-house development. At times cost-containment is also a consideration in the reorganisation of workstations to make better use of available floor space and improve the flow of work. The benefit of keeping costs down for consumers is also given as the main reason for retailers who have adopted a self-service approach. This includes self-service in the purchases of goods as well as in the assembly of goods (especially furniture). Self-service is also a key approach to accessing financial services, and the payment and monitoring of accounts.

The reduction of physical storage space for records (generally aligned with company longevity and increased customer base) is another reason for company adoption of electronic storage and document-management solutions. The concept of the paperless office is gradually taking hold, especially in the financial services industry. Larger and multiple computer screens per employee (in banks and accounting firms) are being adopted to enable easy and simultaneous comparisons between different records or documents.

The general outsourcing of professional and support services to vendor companies and external agencies is also aimed at containing costs. Using the services and knowledge of external IT professionals and technicians and accountants and auditors is a common tactic for both small and large businesses. At times some of these support services, especially for client enquiries and IT technical support, are outsourced to international providers. This enables firms to focus on their area of specialisation and draw on the specialisation of other 'vendor' companies.

LEAN² office concepts have also been applied in some areas. Although such concepts have generally been applied to manufacturing and are in themselves not new, they are beginning to be implemented in office spaces. Concepts of task segmentation are used just as much as multi-skilling and cross-skilling to gain efficiencies. When basic core tasks are done by more junior staff, senior staff are free to concern themselves with more complex tasks, thus decreasing chargeable hourly

² LEAN concepts are about the elimination of waste so that only those spaces, work processes and activities that add value are kept.

rates. Cross-skilling and rostering of staff for a variety of tasks are used in retail companies to increase efficiencies by both increasing employee motivation and the available pool of employees.

Revenue growth

The quest for revenue growth and increased market share is the key aim of large or small commercial companies across industry sectors. This often means searching for new or different opportunities, ideas, processes, techniques, products and services at home and abroad. At times it means using existing knowledge to branch out into other ventures. Across industry sectors there is a conscious effort to attend events (including trade fairs, conferences, and workshops) to ensure that companies remain up to date with the latest trends. Searching for new relationships with potential customers overseas is also a way for breaking into new market areas and setting up business arrangements which will increase revenue. This is especially the case for biotechnology companies searching for new business.

Changes in existing practices are also driven by a need for firms to remain ahead and abreast of their competitors. When a company places a new product or service in the marketplace and it becomes commercially successful, it does not take long for other companies to produce a similar product or service.

Using statistical techniques to predict customer behaviours which lead to revenue growth is fundamental to the banking and insurance and superannuation sectors. These techniques are based on an understanding of customer behaviours and life patterns. The head offices of banks or aggregator broker networks have in place key analytical functions devoted to these areas. Banks have applied statistical modelling procedures to better understand credit behaviours and the needs of borrowers. This information enables banks to market themselves to specific segments of existing and potential customers, and to implement those solutions likely to be most profitable.³ Systematic predictions based on life tables are also used for the development and selling of insurance and superannuation products. In all cases these statistical models are used to develop technical applications which can be used to deliver on-the-spot solutions to customers. In these cases it is not the statistical modelling procedures that are new but the fact that they have been applied to decision-making for loan officers or for financial planners.

The use of statistics for benchmarking organisational performance and analysing customer insights and staff suggestions are also common and provide other incentives for implementing new ways of working. Although such measurement and analysis processes are not new, using an evidence-based approach for decision-making is becoming more widespread.

For small financial services companies (like financial planners and insurance brokers), revenue growth is also augmented by forming alliances or partnerships with others. Financial brokerage and planning firms have found that if they are to be sustainable they will need to identify new ways of interacting with banks and insurance companies, who are generally looking for volume of business. Increasingly, they are forming or joining aggregator networks to increase their buying power and thus their sustainability. Being part of an aggregator group allows brokers and planners to work independently while also benefiting from the general back-of-house technical resources of the aggregator group. Financial institutions, like banks, are interested in supporting such aggregator networks for the volume of activity they engender. Banks themselves are also interested in forging partnerships with financial players, like funds managers. The introduction of the shared equity mortgage is an example of how partnerships between funds managers and banks can be used to enable those who may not be able to afford a housing loan to acquire one.

³ This is not to say that banks are ignoring the needs of customers who are less profitable in terms of credit (that is, those who pay off their credit cards before interest is charged). They like to look after these customers too because such customers may already have existing home loans or may request home loans and other credit arrangements in the future.

Companies in both the retail and financial services industries are increasingly helping clients to improve processes and their understandings of businesses. For example, a major brand manufacturer and wholesaler is currently working with third-party suppliers to ensure that they understand the importance of specific ways of production. A major financial services institution is sharing statistical information on criminal behaviour to help law and order agencies and offering products to help clients assess risk. Demonstrating that they are prepared to add value to the core business of their clients helps such companies maintain customer business and loyalty.

Finding a niche market to sell products and services that will be profitable is another driving force for setting up business. This is true for financial institutions that have commenced operations in regional locations vacated by other banks and subsequently expanded out to metropolitan areas. It is also true for biotechnology firms that take advantage of regulatory provisions for quality assurance under the *Therapeutic Goods Administration* legislation to produce, warehouse and distribute drugs for Phase 1 trials.

Consumer demand

Consumer demand and customer feedback are key triggers for innovation across industry sectors. Firms are doing their best to meet customer needs, since it is their ability to meet these customer wants, preferences and aspirations that will earn them the revenue they seek. Some larger financial institutions have special departments, often aligned to the marketing function, devoted to understanding the behaviours of customers and the consequent design of products and processes to meet their expectations. Smaller companies will keep track of consumer purchases and behaviours either to adjust trading times or to ensure that they stock items in demand.

The marketing and promotion of services is aimed at using knowledge of consumer behaviours, desires and needs to target specific segments. Marketing campaigns for many large firms make use of traditional advertising campaigns, including television, radio and billboards. Increasingly, quirky television advertisements to entertain as well as inform the viewing public and to build company brand are creeping into the marketing of services.

There is a strong interest in using the facility provided by social media (including Facebook and Twitter) and social networking sites (LinkedIn, Myspace) to extend promotional activities and establish contacts for new business. Smaller firms, especially accounting firms, retailers and wholesalers, although aware of the need to use different forms of electronic media to market themselves, continue to be dependent on word of mouth and on loyalty from customers as essential marketing strategies.

Issues and deficiencies

Issues and deficiencies in existing skills, processes and resources are key triggers for innovation. They explain why companies might implement in-house technical training in cases where occupation-specific skills and the knowledge of employees are found to be wanting, or why they might implement major corporate restructuring when economic realities affect the bottom line, as in the recent Global Financial Crisis.

Slowness and difficulties associated with accessing records using historical record-management systems are reasons for upgrading the ways in which records are stored or retrieved. In company mergers, both the need to integrate different organisational cultures and practices and electronic systems will also drive changes in the way work is done.

In all cases the establishment of special problem-solving or continuous-improvement activities which provide forums for thinking about new products and new and better ways of working is especially common in large organisations undergoing change.

Resources for innovation

Implementation of substantial infrastructure development, physical workspace reorganisation, and purchase of state-of-the-art technology, equipment and materials are costly and depend on firms having the funds or the ability to make or acquire funds (including grants from governments) and access to appropriately skilled employees or external consultants and receptive markets. Attending and participating in international and domestic trade fairs, making special visits to potential clients, and mounting marketing or learning campaigns are key elements of finding out what is happening in industry sectors and assisting firms to stay abreast of changing trends and practices.

Objective information about customer behaviours and practices (including purchasing preferences and banking histories) is an important resource in helping companies to make decisions about how to modify products, processes and services. Databases detailing the types of purchases made by customers in major supermarket chains are bought and analysed by commercial data houses and then sold on to retailers and wholesalers. This knowledge provides retailers and wholesalers with hard data about which products are selling or not selling in different locations and enables wholesalers to source or to introduce products onto the market that will attract purchases from customers.

Other approaches to customer needs analyses that have been successful for one major wealth management and insurance company include the use of ethnographic techniques to observe the interactions between financial planners and their customers. These observations form the basis of protocols and scripts for future professional development activities as well as the actual campaigns.

Innovation often requires a champion to drive it. Often such a champion has had experience in implementing new processes or developing new products in other places. The champion who has a key company role has the ability to influence the extent of company resources allocated to seeking out new opportunities or introducing significant change. According to Drucker (2002), it also helps if they are trying to introduce ideas that are 'simple and focussed' (p.102).

The skills required for innovation

When we think about skills required for innovation, it is useful to organise these into typical sets of skills. The ABS Business Longitudinal Survey, which investigates the types of innovative activities implemented in firms, organises skills into ten main discipline areas. These are engineering, scientific and research, IT professional, IT technician, trades, transport, plant and logistics, marketing skills, project management, business management and finance-related skills.

For the retail, wholesale and financial services sectors, the skills that are most important for innovation at the present time and in the future are marketing, business management, finance, and project management skills. These results support the findings of the ABS Business Longitudinal Survey. For biotechnology it is engineering, scientific and research skills and advanced project management skills.

That marketing skills are rated highly in both retail and financial services sectors is not surprising. Knowledge of consumer demands, habits and desires and using this information to drive the development and provision of products and services are essential to the business of the retail and wholesale industries and the retail banking industries. It is also not unusual for commercial businesses to identify business management skills as an important aid to innovation. These skills are often crucial to ensuring that technical operations, administrative processes and customer service functions are proceeding smoothly. Also required is an overarching knowledge of the business and the market in which it operates. This knowledge is key to initiating innovative activities that enhance strategic business.

Highly rated are skills related to finance, especially but not only in financial institutions. An affinity with numbers is required in accounting firms, while business management and project management skills are required in any organisation that deals with large projects or large sums of money. In addition to these specific technical skills, customer service skills, needs analysis skills and communication skills are highly sought after. For biotechnology firms the key skills required for innovation are scientific skills, project and business management skills and finance-related skills. For those involved in statistical modelling and other high-level analytical functions, the key skills required are high-level mathematics and statistics.

Businesses rarely say that they employ their own IT professionals and technicians; they also rarely rank these as being of high importance vis-a-vis other skills. Yet the fact that they are prepared to outsource these skills to external providers and to pay handsome premiums for these indicates that such skills are essential to business operations. In the rare cases where such activities are not outsourced to external specialists (mainly major banks and insurance companies) they are quarantined to IT-specific departments within organisations. In large financial institutions, a combination of internal and external sourcing of IT resources is a common practice. In fact, businesses, however small, will generally hire external providers to customise a company-specific solution for them. They are also prepared to pay monthly or annual fees to ensure that they are provided with the required support. It is interesting that, on occasions, help desks in major banks may not be located internally (and in one case they are located offshore) and that these technician skills are also outsourced. Trade skills are rarely highlighted as being of high importance in these industries, and when they are required, they are generally outsourced. Of course, for small businesses where trade skills are required as part of the core activities (for example, hairdressing), these skills are rated reasonably highly.

Formal project management qualifications are rarely required in many small businesses, although project management skills are often desired. It is not unusual for large firms to outsource the project management of large projects to specialist external contractors and to keep smaller projects for management by in-house employees. Conflict management and negotiation and decision-making skills are especially required of case managers in companies dealing with workers' compensation claims. They need to be able to communicate with clients and their medical practitioners to work out a timeframe for getting clients back into the workforce. The ability to troubleshoot problems, to address issues as they arise in a timely manner, and to schedule the completion of tasks are the key aspects of project management that help innovation, whatever the industry.

Is there a role for VET in innovation?

Our interest in innovation is motivated by the need to understand how the VET system can prepare individuals with the skills and knowledge required to participate in employment. However, firms are not turning to VET graduates when they look for individuals with the skills and knowledge required for promoting products and services; analysing and managing business operations, processes and projects; accounting and auditing books; building statistical models to predict growth and risk; and developing IT systems and databases. They are also not looking to VET for engineering or scientific skills. These they source from university graduates, or in rare cases students still in university studies. Firms do look to VET to source skills typically associated with vocational training (including trade and IT technician skills, bookkeeping skills, and financial planning skills). Where individuals have basic degrees (say in accountancy), then firms would also like them to pursue Certified Practising Accounting (CPA) or Chartered Accountant (CA) designations. VET diplomas or advanced diplomas in accounting will be considered, with the proviso that they be followed up by the completion of a university degree.

There may be two reasons for this: firms may sincerely believe that high-level theoretical, analytical and problem-solving skills can only be developed in universities, or they may not know that some

occupational skills can also be learnt in VET programs. Although university education has traditionally been the source of more advanced and complex skills (including high-level mathematics, statistical modelling, software and design engineering, scientific research, mechanical engineering), there are also VET diplomas or advanced diplomas to be gained in areas like accounting, engineering, marketing, financial planning, business management, project management, and transport and logistics.

Not all firms seek qualifications or a specific educational background when recruiting employees. The great majority require and desire employees who have specific on-job experience and desirable personal attributes. This is the case whether or not individuals have university or VET qualifications. All firms will use on-the-job training to develop the competence of existing workers, new recruits and future leaders. In some cases changing the recruitment focus to hiring the right person rather than the right skills has also been used, especially in organisations seeking a culture change. Firms wanting to project a certain image or lifestyle will base their recruitment decisions on people who either live the lifestyle of the products being sold and marketed, or who can project the appropriate image. They will undertake on-the-job training or be coached by skilled and experienced work colleagues in other aspects of the job. Firms may employ a person who displays what they feel is the right attitude, claiming that the individual can be trained to meet company-specific needs. There is also a view that sometimes company knowledge is so specific that potential employees are unlikely to possess it.

When representatives of larger companies are asked to identify the sources of current or future skill needs, they specify university graduates. This is often because larger companies (especially, but not only financial institutions like banks and superannuation companies) have already decided to implement graduate, leadership and management development programs to enhance their workforces. Hence, it is not surprising that they prefer university training as key to succession planning for future roles.

It is also the on-the-job experience and training, along with personal competence, that enables those with no formal post-school qualifications to compete with graduates in the internal corporate marketplace and attain high-level management jobs in firms. Typically, those people who do not have higher education qualifications but who have been very successful in attaining high positions are not totally convinced of the need for high-level post-school qualifications—or any qualifications for that matter. They recognise that knowledge and experience have been essential to their own career development and to the successful performance of others.

If firms believe that it is university rather than VET qualifications that are more important for innovation, then what does this mean for VET? We must first question whether or not there is sufficient awareness of the types of programs and qualifications on offer in VET. If firms are not aware of the type of training offered in VET, then perhaps marketing or promotional campaigns to increase awareness of the scope of VET training may be an answer. If perhaps the skills and knowledge offered by VET are not well regarded, then this is a more difficult issue.

Second, we need to understand whether some skills and knowledge (typically identified as requiring university training) can also be taught in the VET space. We cannot deny that there are territorial issues across education sectors with regard to the provision of certain professional skills and knowledge. Engaging in this debate may lead us to a dead end, as different sectors will have their entrenched views about what is a professional vocation and what is not. We can, however, promote partnerships between VET providers and universities such that VET graduates are also eligible to enter university programs with the maximum amount of credit for their VET learning. Another solution would be for VET providers to partner with professional associations like the Institute of Chartered Accountants and the Association of Certified Practising Accountants to enable VET and university graduates with accounting qualifications to attain CPA and CA designations.

VET also has a role in the provision of the short programs required for existing workers. Companies are increasingly looking for IT solutions for the development, storage and retrieval of electronic documents, while companies involved in financial planning are looking to develop basic bookkeeping skills and similar financial skills in their staff. Companies are also looking for good project management and business management skills. Training in these skills can be provided by VET, working in conjunction with firms. Partnerships such as these are not new to VET and many providers are already providing work-based learning programs for firms. There may be a need for VET to increase this type of provision. Companies are relying on vendor companies to look after their IT requirements and technical support. VET providers could work in conjunction with vendors to provide on-the-job training for vendor employees as well as to develop the technical skills of technicians.

Concluding remarks

At various times different views have prevailed about the way firms work or should work that capture the imagination of writers, social commentators, organisational theorists and business consultants. Such views sometimes take on the mantle of practical truths and thus are hard to resist or dispel. Innovation is a case in point. An accepted view among many commentators is that, unless firms are constantly searching for or implementing innovative activities, their economic success in the short term will be limited or unsustainable in the future. Such rhetoric has been more influential in some companies and industry sectors than others.

The promise of economic benefits flowing from the pursuit of innovation may be hard to resist for companies looking to expand their market share, stay ahead of competitors, or improve other measures of organisational performance. For such firms there is a danger that they may not fully understand that innovation may be a risky business. With no funding to support their development into products or processes, good ideas may fail. They may also fail if those who are entrusted to their development lack the required commitment or ability to move the idea through its various implementation stages. They may also fail if consumers do not see value in buying the products or services offered, or if it is more trouble to change the existing ways of doing things.

We have found that the main drivers of innovation in financial services and retail and wholesale firms are related to their desire to keep costs down, maximise profits, and expand market share. For the biotechnology industries, the driver for innovative activities is the search for niche opportunities to expand their market share. This means that firms are not pursuing change for its own sake or accepting the view that they must be constantly innovating to ensure economic sustainability. They are being far more circumspect and conservative in their approach to innovation and only adopting those elements that are absolutely necessary. Innovation may be heralded as the way of the future, but for firms it has a clear purpose and practical application. These are tied up with the economic realities of their internal and external business environments and the constant quest for increasing revenue while containing costs.

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The role of education and skills in Australian management practice and productivity

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This chapter reports on a study into management practices and relates these practices to the characteristics and capabilities of managers, their enterprises and various aspects of enterprise performance. The findings of the study provide a unique insight into the ‘intangible’ factors at work in the determination of productivity and performance in a globalised economy. In particular, the findings suggest that higher skills and education levels, both for managers and their workforces, are positively and significantly associated with the ability to develop and deploy superior management practices. Secondly, ‘people management’ practices are critical to the improvement of overall management performance, and yet this is an area in which Australian firms most conspicuously lag behind global best practice, especially in the ability to ‘instil a talent mindset’. Finally, the findings in both Australia and the other countries in the study demonstrate that high-performing management is a key driver in the promotion of more innovative and productive enterprises.

Introduction

The Australian Government recognises that higher rates of productivity growth are essential to sustaining future economic development. There is a shared concern among researchers and policy-makers that Australia’s recent commodity boom has masked a structural deterioration in the economy’s productivity performance, with damaging implications for long-term growth and prosperity. However, there is less agreement on the causes of this deterioration and on actions that can be taken to improve performance. In 2008 the Australian Government initiated a review of the National Innovation System. This review identified management and workplace innovation as a factor in productivity performance, but did not quantify its impact. In this context, the White Paper *Powering ideas: an innovation agenda for the 21st century* (Commonwealth of Australia 2009) instigated a ten-year program for public research and business innovation. The paper recognised that innovation is much more than science and technology and is increasingly encompassing ‘organisational innovation’—such as new business models, systems integration and high-performance work systems. The White Paper made it clear that a future focus of the government’s industry and innovation policies will be on ‘building innovation capacity and performance at the enterprise level’ (Commonwealth of Australia 2009, p.17) and that: ‘Making innovation work requires a workforce with sophisticated skills of all kinds—including leadership and management skills’ (p.44).

This echoes earlier research contained in the Karpin Report (1995) on leadership and management skills, as well as in interpretations of a series of Australian workplace employment relations surveys (Alexander & Green 1992); these have been among the few systematic studies in Australia over the

past two decades to measure management practices within firms and to assess their impact on performance and productivity. This lack of reliable empirical data on management has hampered the progress of research that analyses and attempts to understand the linkage between management practices and corporate, industry and national economic performance. For this reason it was timely for the innovative research methodology designed by Nick Bloom and John Van Reenen (2007) to be applied in an Australian context (commonly referred to as the Australian Management Practices [AMP] research study).

This chapter reports on the outcomes of the research study, entitled *Management matters in Australia – just how productive are we?* (Green et al. 2009). Sponsored by the Department of Innovation, Industry, Science and Research (DIISR) and undertaken by the University of Technology, Sydney, and the Macquarie Graduate School of Management, this research study was part of a major global study conducted in 16 countries and led by the London School of Economics (LSE) and McKinsey & Co. Through it, management practices in manufacturing firms were accurately and reliably measured and their impact on productivity and performance was assessed.

This chapter will focus on the role of education and skills in Australian management practices, innovation, and productivity, including the role of VET. Essentially, the study undertakes an analysis of management practices and relates these practices to the skills and education levels of managers, thus providing a unique insight into the ‘intangible’ factors at work in the determination of productivity and performance in a globalised economy. The findings suggest that higher skills and education levels (both for managers and their workforces) are positively and significantly associated with the ability to develop and deploy superior management practices. Further, the findings suggest that ‘people management’ practices, a component of overall management practice, are critical to the improvement of overall management performance and, in particular, to innovation and productivity.

Australia’s productivity performance in manufacturing

The Australian economy has experienced average annual gross domestic product (GDP) growth rates ahead of many other developed economies, with an average growth rate between 1998 and 2008 of 3.5%. However, our GDP per capita rank has dropped three positions over the past decade to seventeenth in the world in 2009. During the 1990s Australia was a world leader in productivity growth; however, since 2003–04, our productivity growth rate has declined to a level that is no better than that achieved in the 1960s (ABS 2008a). According to the World Economic Forum’s Global Competitiveness Index (Porter & Schwab 2008), Australia’s economic performance has also slipped from fifth to fifteenth over the past eight years, which further suggests that there is a flattening trend in productivity, with economic growth and prosperity potential not being realised.

In this context, perhaps no industry is under more pressure than manufacturing. This sector is central to our economy as it makes a substantial contribution to output, employment, productivity, exports, and, consequently, economic growth. Manufacturing as an industry sector accounts for approximately 10% of the Australian economy, but it remains a growth engine for knowledge-intensive products and processes. However, the key findings of the Australian Industry Group’s special survey on Australian business and the global economic and financial crisis noted that: ‘Manufacturing remains the sector hardest hit, with 80% of business identifying negative impacts’ (Australian Industry Group 2009, p.1). Hence it is imperative that we look at new sources of growth and ways to accelerate and enhance productivity within this sector, as advised by the recent OECD report, *Review of regulatory reform Australia: towards a seamless national economy*: ‘Australia still has a challenge to lift productivity to return higher long-term growth and continued future prosperity’ (OECD 2010a, p.13).

Managerial innovation—Australia’s source of future competitive advantage

A paradigm shift in Australia’s economy has led to a structural change, from traditional, scale-based manufacturing (which mainly relied on tangible assets), to a service and knowledge-based economy with increasing innovation-oriented activities (which rely largely on intangible assets—human capital and knowledge). Thus knowledge and intellectual assets are becoming key strategic resources for firms seeking to generate economic value, with concomitant benefits for the overall economic growth of the nation. However, until this new knowledge is translated into new economic and social value, it will not be successfully exploited and put to practical use.

Australia has a high proportion of small and medium firms; it is therefore important that the innovation performance of small and medium firms is lifted. The critical role that management talent has in small-to-medium enterprises in driving innovation, competitiveness and growth in the modern economy cannot be underestimated. Managerial workforce skills are underpinned by collaboration and are critical for innovation within and across enterprises, and across nations. However, in a recent survey conducted by the Open Forum for the Society of Knowledge Economics (2008a), key impediments to the fostering of innovation were identified as: a short-termism in political and business thinking; under-investment in education and infrastructure; and ‘risk-averse’ and ‘insurance driven’ attitudes. Accordingly, a change in behaviour and mindset is required of Australian managers and their workforce environments to drive firm competitiveness and output to their full potential.

Australian Bureau of Statistics (ABS 2008b) data indicate that the propensity of innovation in the Australian manufacturing sector was at par with average industry standards—especially in the areas of operational process innovations, marketing methods and managerial innovations, but it was below the average industry standard for the introduction of new goods or services. In short, Australia is modest in its achievements and needs to boost its efforts in this area. This paper will show that development of Australia’s human capital through investments in education and skills and in management practices as a supporting platform for its delivery is a key step towards this end.

Intangible factors are important in the determination of productivity and performance

Paul Krugman, the 2008 Nobel Laureate in Economics stated in 1997: ‘Productivity isn’t everything but in the long-run it is almost everything’ (Krugman 1997, p.9); that is, over the longer term, productivity growth is the most important factor driving national competitiveness and growth. Further, according to a Treasury report in the United Kingdom (Great Britain Treasury 2000), productivity is driven by five drivers: skills, enterprise, investment, innovation and competition. Undoubtedly, skills have a crucial role in stimulating productivity growth, with several studies urging increased investment in workplace training to improve nations’ international competitiveness and long-term economic performance and to address the ‘skills gap’ (Black & Lynch 2004; Richardson 2007; O’Hanlon-Rose 2008–09; Green et al. 2009; Toner 2007, 2009).

Economic theory posits human capital as the engine of economic growth with ‘economic competencies’ (OECD 1998), including brand equity, firm-specific human capital and organisational capital creation, as the key determinants (Nelson & Phelps 1966). Until recently, theoretical and empirical analyses at the macroeconomic and microeconomic levels have investigated both the determinants that drive innovation and its contribution to firm performance—as productivity growth and/or market value. However, measures of innovation have been broadened to include innovation resources, innovation effort, innovation outcome, and innovation performance (Cosh, Hughes & Lester 2006). The OECD’s *Innovation strategy report* (2010b) highlights that in some OECD countries firms now invest as much in the intangible assets related to innovation (R&D, software, skills, organisational know-how and branding) as they do in

traditional capital such as machinery, equipment and buildings. From this we can infer that investment in education and skills is paramount and that ‘innovation is considered one of the main drivers of productivity growth’ (OECD 2009, p.112) in OECD nations.

According to Laplagne and Bensted (1999, p.46):

Labour productivity growth appears to be enhanced by the joint introduction of training and innovation. This is due to the fact that training requires the support of innovation to benefit labour productivity growth. Conversely, introducing innovation in isolation is sufficient to promote labour productivity growth, although its returns are increased by the addition of training.

Productivity growth relies on a continual stream of innovations of both new technologies and improved work practices. New and innovative ways of working provide a source of efficiency gains, enabling workers to operate more effectively, thus providing firms with greater opportunities to use labour and capital inputs in ways which will maximise their productive potential.

The questions that remain unanswered are: just how important to innovation and productivity are skills relating to management practices, and what is the extent of the contribution that skills make to management practices, in particular towards people management practices? What role do human resource practices, education, and skills play in achieving higher firm performance and productivity? Why is a nexus between innovation and skills deemed essential for fostering human capital and tacit management capabilities within enterprises?

Management practices are key to value creation, innovation and productivity

Australia is falling behind other leading nations in a number of areas that demonstrate ability in modern business and management practices (table 1).

Table 1 Areas where Australia is lagging behind

Category	Australia's rank	Number one
Business Competitive Index	18th	USA
Capacity for innovation	30th	Germany
Sophistication of company operations and strategy	24th	USA
Production process sophistication	23rd	Germany
Willingness to delegate authority	14th	Sweden

Source: Porter and Schwab (2008).

In recent years a number of researchers have attempted to quantify the impact of management practices on productivity and firm performance; for example, the London School of Economics (LSE), which has spent six to seven years developing a new approach for the robust measurement of firms’ management practices, concluded that:

Across all the firms in the research, a single point improvement in management practice score is associated with the same increase in output as a 25% increase in the labour force or a 65% increase in invested capital. (Bloom et al. 2007, p.5)

According to traditional models, value creation focuses on firm output and price; however, contemporary definitions encompass all types of value, tangible and intangible, both within organisations and across economies (Teece 2009). Value creation is a concept which is deeply embedded in the foundations of economics and in the study of market exchange (Smith 1994 [1776]). Given the constant tension between opportunities and threats, organisations today are subject to demanding pressures: firms need to manage risks, gain additional influence over customer demand, and generate new ways of creating value. For this reason, management practice is indeed seen as one of the ways in which such value can be created (Society for Knowledge Economics 2008a; Green et

al. 2009). A vast literature exists to support the view that changes in the workplace, team structures, communications and managerial leadership all affect firm-level productivity and workforce efficiency (Dutton & Thomas 1984; Society for Knowledge Economics 2008a).

Further reinforcing the importance of management practices, a recent study by Alexopoulos and Tombe (2009) suggests that the development of intangible processes and management techniques improve productivity significantly. Factors such as physical capital, human capital and technological progress are also essential components in productivity growth, at the level of the economy and the organisation. Cosh and Hughes's (2000) survey on small and medium-sized enterprises provides some indication of management skills as being a significant determinant of firm productivity growth. A more skilled workforce is likely to be more productive and self-sustaining, thereby providing a source of economic growth. Therefore, investment in physical and human capital contributes to knowledge capital, in turn raising labour productivity not only via factor accumulation, but also by stimulating the creation and dissemination of innovations.

Skills and education are imperative for the workforce

The Bradley Review (Commonwealth of Australia 2008, p.xi) acknowledges the implications of under-resourcing higher education for Australia's global competitiveness:

Australia is falling behind other countries in performance and investment in higher education. Developed and developing countries alike accept there are strong links between their productivity and the proportion of the population with high-level skills. These countries have concluded that they must invest not only to encourage a major increase in the numbers of the population with degree-level qualifications, but also to improve the quality of graduates.

Consequently, education plays a major role in fostering the skills sets required for leadership, management and innovation. When people become more educated, their ability to engage, participate and understand increases correspondingly. The WorkUSA survey, *Driving business results through continuous engagement* (Watson Wyatt Worldwide 2008–09), demonstrated that, when employees are highly engaged, their companies achieve higher labour productivity and lower staff turnover and provide higher returns to shareholders. Further, Black and Lynch (2004) suggest that a third of US output growth stems from productivity-enhancing organisation innovations at the workplace level, while a UK-based study found that:

If we can increase the performance of just 10 per cent of the bottom two thirds of UK firms to the average performance of the top third, this would add around £1,600 added value per worker per annum – contributing £2.5 billion to the UK's total GDP, raising the trend rate of growth of the UK economy by around 0.25 per cent each year. (Work Foundation 2003, p.18)

International and Australian research evidence suggests that workforce skills and capabilities are a key factor in the creation of a high-productivity, high-wage economy, while at the same time contributing to organisational innovations. While this resonates with the Australian Government's 'education revolution', it is also important to understand how skill development in the broader context of knowledge and innovation is an 'unexplained residual'. This currently unmeasured skill development component should be quantified in relation to productivity, innovation and firm performance. Hence, the promotion of innovation, productivity and skills agendas—by the Australian Government (and industry)—is at a critical stage. Concurrently, there is also an increased demand for a human capital talent model with a range of differentiated capabilities, including enhanced management and leadership skills, talent culture and collaboration dexterities (Aguirre, Hewlett & Post 2009).

In the context of both producing and attracting the human capital needed for innovation, the recent OECD strategy report strongly endorsed the need to acquire skills through formal education, training, experience and other forms of informal learning:

Human capital is the source of innovation ... vocational education and training play an important role in innovation ... Moreover, the acquisition of skills is a lifelong process; it does not end with formal education. The ongoing acquisition of further skills needs to be encouraged. (OECD 2010b, p.79)

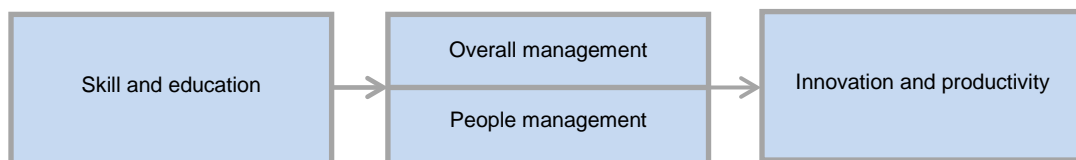
In understanding the significance of the skills and education of managers and their workforce in articulating the role of intangible assets for innovation and productivity outcomes, this chapter further sharpens thinking about these assets as one of the key structural determinants of a knowledge-based economy. Undoubtedly, it is our people, skills and organisation capabilities that are core to addressing this raft of complex challenges in an environment that is changing in unprecedented ways and at unprecedented speeds. Industry now demands ‘dynamic capabilities’—new routines, tools and processes to adapt to a changing economy (Teece 2009)—a concept articulated by several researchers in varying contexts. The concept also encompasses the impact of higher-order competencies on innovation in service value networks (Agarwal & Selen 2009) and the role of knowledge management processes behind dynamic capability building (Cepeda & Vera 2007). Further, recent literature also emphasises the role of dynamic capabilities in emerging economies such as China (Zhou & Li 2010) and the applicability of dynamic capability under environmental volatility (Wu 2010).

An emphasis on the role of dynamic capabilities in promoting and sustaining high levels of productivity is consistent with the recommendation of the Australian Management Practices study (Green et al. 2009, p.39), which states that manufacturing firms:

need not only to foster and inculcate the process of dynamic capability building through collaboration, but also should take measures to inculcate, promote and manage higher order skill sets for innovation, be they product, process, organisational or managerial innovations.

In response to this requirement, we next present an overview of Australian and global positioning of management practices in the manufacturing sector. Thereafter, we examine the relationship between three related topics: skills and education; management practice, people management; and innovation and productivity as depicted in the framework shown in figure 1.

Figure 1 Relationship between skills and education, overall management practice, people management, and innovation and productivity



Research methodology—measurement of management practices

The innovative research methodology originating from the London School of Economics was applied to the measurement of management practices across 16 different countries, including Australia. The key to this methodology is a conversation-based interview scoring grid which uses the concepts of ‘double blind, double scoring’. The grid contains 18 dimensions collated into three broad areas of management: operations management (seven practices); performance management (five practices); and people management (six practices), with the overall management score defined as the average across the 18 dimensions. The criteria for scoring management practices from one (worst practice), to three (average practice), to five (best practice), are clearly defined (see appendix A taken from Bloom & Van Reenen [2007]).

In 2009, the London School of Economics research study was authentically and accurately replicated in Australia. The interviewers were given specialised training to ensure consistency in standards and to allow for global comparability with the other countries where this research had already been conducted. The team interviewed 439 randomly chosen medium and large manufacturing firms in Australia (firm size 50–5000). Approximately 80% of all interviews were ‘double scored’, in that, while they were run and scored by a main interviewer, they were also listened to and independently scored by another team member.¹ This technique aided in minimising measurement errors, which was evident from the high correlation between the scores of the interviewers and listeners, at 95%.

Management calibre in Australian manufacturing firms

This section provides a brief overview of the findings from the Australian Management Practices study, with a focus on Australia’s positioning in management practices globally and domestically.

Australian managers perform close to the global average

Australian management practices rate marginally above average when benchmarked internationally, ranking sixth among the 16 participant countries. As shown in figure 2, Australia falls in the second tier of countries in terms of its management performance, with statistical parity with France, Great Britain and Italy. However, Australia significantly lags behind the best-performing countries—the United States, Sweden, Japan, Germany, and Canada.

Figure 2 Overall management score by country showing tiers in performance



Source: Green et al. (2009) dataset; LSE global study dataset.

Table 2 summarises the management scores for Australian firms in the areas of operations, performance and people management.² These findings are consistent with the research conducted by the Society of Knowledge Economics (2008b, p.32), which indicated that: ‘Australia lags behind in terms of business management and innovation capabilities at the workplace level’.

¹ As per Australian regulation, interviewees were informed of their call being monitored for quality and control purposes.

² Firm size 100–5000 based on data collected across 385 firms excludes firms with fewer than 50 employees to allow for management score comparability across the world.

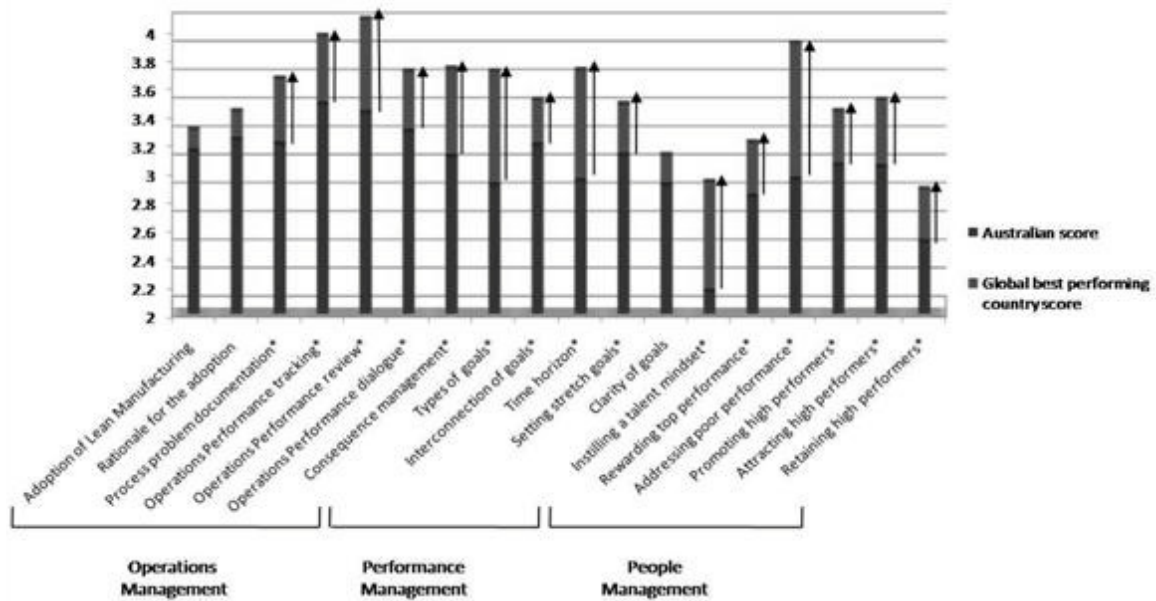
Table 2 The distribution of Australian management scores (firm size 100–5000)

Variable	Observations	Mean	Std. dev.	Min	Max
Management	385	3.02	0.57	1.11	4.44
Operations	385	3.26	0.70	1.00	4.86
Performance	385	3.00	0.72	1.00	4.60
People	385	2.74	0.53	1.00	4.33

Source: Green et al. (2009) dataset.

The specific dimensions within the broad management areas of operations, performance and people management, where Australia’s score trails behind the global best-performing nation, is shown by vertical arrows in figure 3. Importantly, the top-performing countries, the US and Sweden, are also amongst the top four competitive economies in the world (Porter & Schwab 2008). This indicates that improving management performance is a key factor in longer-term sustainable growth for Australia. Further, the Australian Management Practices study (Green et al. 2009, p.3) also concluded while ‘... some of our firms are as good as any in the world, we still have a substantial “tail” of firms that are mediocre, especially in their approach to people management’. Australia needs to focus on its management practices across all three dimensions, but in the people management space, Australia lags far behind the best-performing nation, especially in ‘instilling a talent mindset’ and ‘addressing poor performers’.

Figure 3 Gaps in the AMP performance across the three dimensions of management practices



Note: * Indicates Australian score statistically significantly different from the global best-performing country’s score—based on statistical analysis at the 10% significance level. Canada is excluded from the statistical analysis of individual questions as the firm-level data of Canada were not available. AMP = Australian Management Practices (study).

Source: Green et al. (2009); LSE global study dataset.

At a global level Australia is weak in people management

The United States, Canada and Germany deliver exceptional performance in the people management area. However, Australia’s performance relative to global best practice is statistically worse across all six dimensions (table 3). What this tells us is that Australian businesses must improve their practices relating to human resources in order to attract and promote the best

talent and address poor performers. Further, the firms need to instil a ‘talent mindset’ amongst their workforce.

Table 3 People management practices performance compared with the global best

Area of management – people management	Australia's global ranking*	Global best performer*
Overall score	8	US
Instilling a talent mindset <i>Best practice:</i> senior managers are evaluated and held accountable on the strength of the talent pool they actively build; <i>Worst practice:</i> senior management does not communicate that attracting, retaining, and developing talent is a top priority.	12	US
Rewarding top performance <i>Best practice:</i> the firm provides ambitious stretch targets with clear performance-related accountability and rewards; <i>Worst practice:</i> people within the firm are rewarded equally, irrespective of performance level	4	US
Addressing poor performance <i>Best practice:</i> poor performers are moved to less critical roles or out of the company as soon as weaknesses are identified; <i>Worst practice:</i> poor performers are rarely removed from their positions.	9	US
Promoting high performers <i>Best practice:</i> top performers are actively identified, developed, and promoted; <i>Worst practice:</i> people are promoted primarily upon the basis of tenure.	8	US
Attracting high performers <i>Best practice:</i> the firm provides a unique value proposition to encourage talented people to join the company instead of the competitors; <i>Worst practice:</i> competitors offer stronger reasons for talented people to join their companies.	8	Japan
Retaining high performers <i>Best practice:</i> managers do whatever it takes to retain top talent; <i>Worst practice:</i> managers do little to try and keep the top talent.	6	US

Note: *Canada is included for the statistical analysis of overall score, but is excluded from the statistical analysis of individual dimensions as the firm-level data of Canada are not available.

Source: Green et al. (2009); LSE global study dataset.

Australian management practices in the domestic setting

We now examine the landscape of management practices in Australia. It is noteworthy that the inclusion of smaller firms (50–99) led to a relative decrease in the management scores when data were analysed across all 439 firms³ (table 4), by comparison with scores obtained for global benchmarking purposes (table 2).

Table 4 The distribution of Australian management scores (firm size 50–5000)

Variable	Observations	Mean	Std. dev.	Min	Max
Management	439	2.98	0.58	1.11	4.44
Operations	439	3.22	0.70	1.00	4.86
Targets	439	2.96	0.74	1.00	4.60
People	439	2.71	0.52	1.00	4.33

Source: Green et al. (2009) dataset.

Focusing on people management scores, our findings reinforce that people management is a weak area for Australian firms, with an average score of only 2.71. Very few firms have a score above 4.3—indicating that they are extremely well managed in this area; however, about 10% of firms have a score below 2, clearly indicating vast scope for improvement in the people management

³ Firm size 50–5000.

sphere. When the smaller firms (50–99) are included, the people management score across the six dimensions in descending order of performance is as follows: promoting and attracting high performers; addressing poor performers; rewarding top performers; retaining high performers; and instilling a talent mindset. The last dimension is the worst performer and therefore requires more attention.

We can conclude that Australia's position in people management both at global and domestic levels is lagging, and that the poor performance in the people management practice of 'instilling a talent mindset' is of concern and requires attention.

Next, we focus on one of the key 'intangible' factors at work in the determination of innovation and productivity—skills and education.

Skills and education—a determinant of management practices

Skill is an important driver of management practices and focuses on the quality of labour inputs. Governments have a particular responsibility in the provision of skills. The multifaceted nature of skills acquisition needs to be emphasised, since individuals acquire skills through formal education, training, experience and other forms of informal learning (Toner 2007, 2009). There is no doubt that a more skilled workforce is likely to be more productive and so itself will act as a source of growth (Benhabib & Spiegel 1994). On the other hand, the potential that resides in our workforce is not fully realised, meaning that policy-makers and executives alike could look to workplace reform to convert unrealised potential into improved firm performance, productivity and employee wellbeing, for the ultimate benefit of Australian firms (MacLeod & Clarke 2009).

The management practices research conducted by the London School of Economics (Bloom et al. 2007; Bloom & Van Reenen 2007, 2010) and the Australian Management Practices research study (Green et al. 2009) have shown that the skills and education levels of managers and their workforce are key determinants of management practices. The percentage of managers and non-managers within the firms who have a university degree is therefore used as a proxy for skills index.⁴

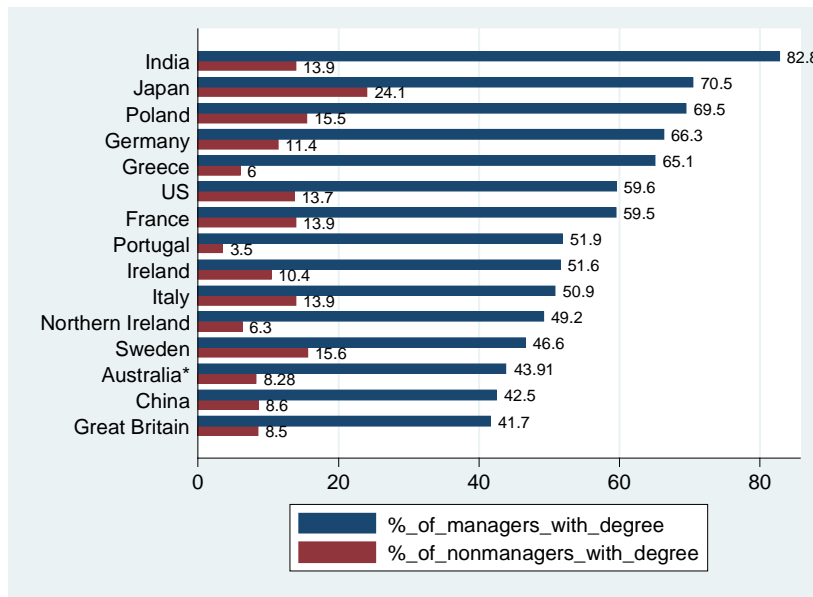
Skill and education—Australia's global ranking

The global study's findings conducted across the 15 countries (excluding Canada) suggest that: 'The availability of skilled people, both in management and among the workforce in general, is another important difference between better managed firms and the rest' (Bloom et al. 2007, p.8). However, the skill level within Australian manufacturing firms⁵ is among the lowest in the world, with Australia ranking thirteenth. With an average of only 44% of managers and a mere 8% of non-managers in the firm sample having a university degree, this is an area where Australia is clearly behind (figure 4).

⁴ These data on education include only university degrees and not college or vocational qualifications.

⁵ Firm size 100–5000.

Figure 4 Level of education—a global comparison

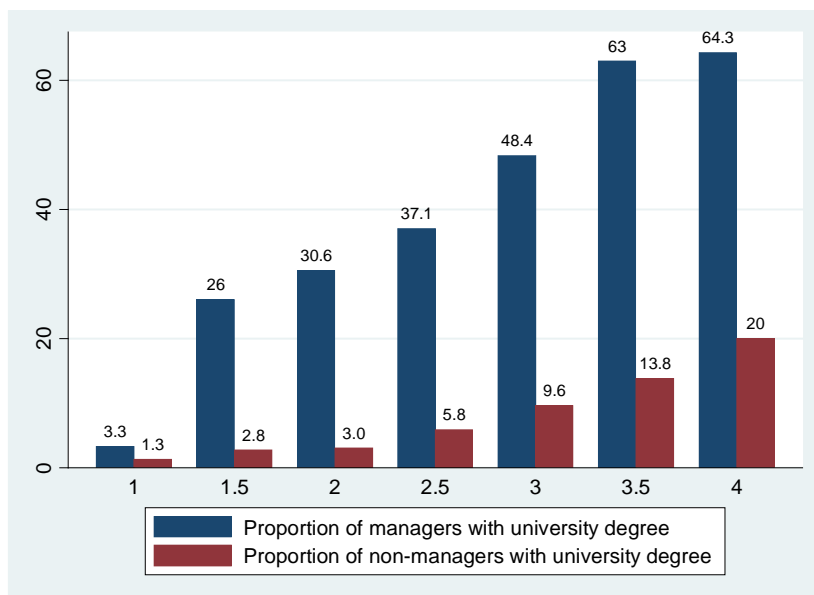


Note: Canada is not included.
 Source: Green et al. (2009); LSE global dataset.

Skill and education—a determinant of Australian overall and people management practices scores

In the Australian context, the positive impact of skills on management practices is evident from figure 5, where manager and non-manager skill levels are grouped in increments of 0.5 of their management scores: 64% of managers in the highest-scoring firms possessed an undergraduate degree or higher, as did 20% of the non-management workforce. By contrast, among the lowest-scoring firms, only 3% of managers and only 1% of the wider workforce had university degrees.

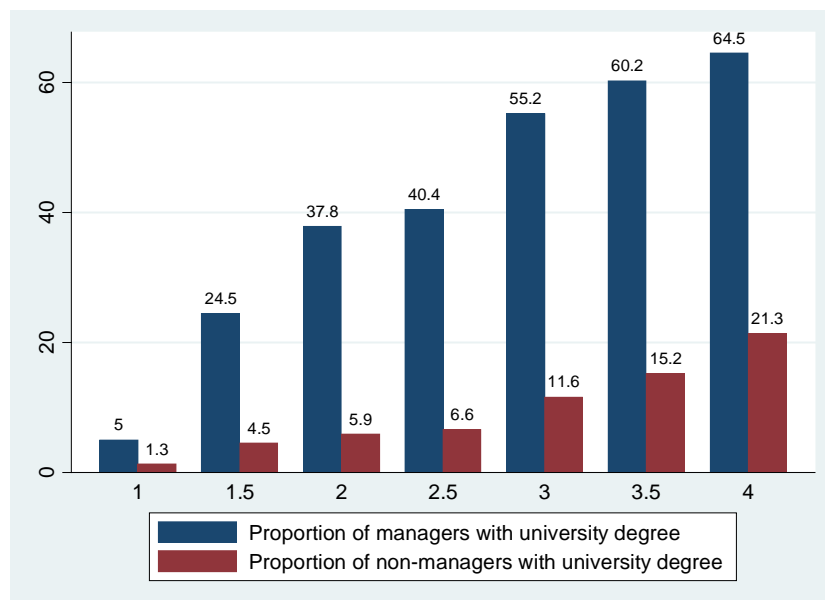
Figure 5 Overall management scores (x-axis) by education levels of managers and non-managers (y-axis)



Note: Firm size 50–5000.
 Source: Green et al. (2009) dataset.

With our focus on human capital, firms in a high-skill environment may have better human capital management practices than those in a low-skill environment (Bloom et al. 2007; Caroli & Van Reenen 2001). Our research once again confirmed that firms with higher employee skills and education have significantly better people management practices (figure 6).

Figure 6 People management scores (x-axis) by education levels of managers and non-managers (y-axis)



Note: Firm size 50–5000.
Source: Green et al. (2009) dataset.

Table 5 shows the results of regression tests between different management practices scores and the education and skill measures. Importantly, the proportion of managers and non-managers with university degrees explains approximately 6.84% and 4.59% of the variability in overall management scores and 3.21% and 2.85% of the variability in people management scores respectively, with both regressions being statistically significant ($p < 0.05$). The same holds true for the other sub-areas of management practices.

Table 5 A summary of the regression findings for management scores by education levels of managers and non-managers

	R² value – proportion of variability in management score as explained by managers with a degree	R² value – proportion of variability in management score as explained by non-managers with a degree
Overall management score	6.84	4.59
Operations management score	6.40	3.86
Performance management score	6.21	4.88
People management score	3.21	2.85

These findings support the Australian Government’s commitment in *Powering ideas* (Commonwealth of Australia 2009) to: ‘Improve innovation skills and workplace capabilities, including management and leadership skills—building on Enterprise Connect and the Education Revolution’ (p.6).

In summary, the findings reinforce the notion that skills and education have a positive and significant influence on the people management practices adopted by manufacturing firms.

Skill and education—a cross-examination of different sub-groups of manufacturing firms

To reinforce our findings, we next examine the level of education and skills as determinants of overall and people management practices in two specific contexts—firm size and overall management score.

Sub-group based on firm size

In this section we examine the impact of education and skills on overall management practices and its three components—operations, performance and people management—based on firm size: small-sized firms (50–99); medium-sized firms (50–199); and large-sized firms (≥ 200).

Table 6 shows the results of the analysis. The unshaded areas indicate that the impact of education on management practices is significant, while the grey areas show where findings are not significant. The summary of the results are as follows:

- ✧ Smaller firms (50–99) notably underperform across all areas of management, the difference in scores being statistically significant. As the Australian economy has a larger proportion of small firms, the performance of this cohort is certain to have a significant impact on economy-wide productivity performance.
- ✧ Smaller firms have a significantly lower proportion of both managers (36.9%) and non-managers (4.89%) with a university degree compared with their larger counterparts.
- ✧ Education levels among managers and non-managers in small firms have a statistically significant impact on performance management. Overall management is critical to effective decision-making by managers, which possibly explains the significant relationship between manager education levels and overall management scores. Operations management is key to non-managerial practices, potentially explaining why the non-manager education level statistically significantly impacts on the operations management score.
- ✧ For medium-sized firms, the education levels among both managers and non-managers have a statistically significant impact on management performance across all areas.
- ✧ Large-sized firms outperform their medium-sized counterparts in all areas of management.
- ✧ Larger firms tend to have a significantly higher proportion of both managers (47.11%) and non-managers (9.89%) with a university degree compared with the remaining firms, and the difference is statistically significant.
- ✧ The proportion of variability in management scores as explained by managers and non-managers with a university degree was found to be important and statistically significant across all areas of management practices and across all firm sizes.

Based on this analysis, we conclude that, irrespective of the firm size, higher skills and education levels result in better management performance. This again reinforces that education and skills are crucial for all firms and that management talent is vital to achieving success.

Table 6 Sub-group based on firm size

	50-99 firm size vs rest of the cohort (>= 100)											
	Australian firm size 50-99				Australian firm size 100 and beyond				Medium firms (50-199) vs large firms (> = 200)			
	Management score	R ² value – proportion of variability explained by managers with a degree	R ² value – proportion of variability explained by non-managers with a degree	Management score	R ² value – proportion of variability explained by managers with a degree	R ² value – proportion of variability explained by non-managers with a degree	Management score	R ² value – proportion of variability explained by managers with a degree	R ² value – proportion of variability explained by non-managers with a degree	Management score	R ² value – proportion of variability explained by managers with a degree	R ² value – proportion of variability explained by non-managers with a degree
Overall mgmt	2.67	8.91(s)	8.89(ns)	3.02	6.76(s)	3.759(s)	2.74	5.25(s)	6.0(s)	3.12	7.08(s)	2.73(s)
Ops mgmt	2.89	1.99(ns)	13.77(s)	3.26	6.07(s)	2.74(s)	3.01	4.90(s)	41.15(s)	3.34	4.90(s)	4.15(s)
Perf. mgmt	2.61	5.76(s)	20.42(s)	3.01	6.61(s)	3.89(s)	2.66	4.07(s)	4.25(s)	3.14	4.07(s)	4.25(s)
People mgmt	2.45	1.00(ns)	2.27(ns)	2.74	3.04(s)	2.27(s)	2.5	2.63(s)	6.37(s)	2.84	2.63(s)	6.37(s)

**Managers with degree significantly lower in small firms 36.9 vs 44.75%.
Non-managers with degree significantly lower in small firms 4.89 vs 8.79%.**

**Managers with degree significantly higher in large firms 47.11 vs 38.33%.
Non-managers with degree significantly higher in large firms 9.89 vs 5.76%.**

Sub-group based on management practices score

In this section we examine the impact of education and skills on overall management practices and its three components—operations, performance and people management—based on the management practices score for the bottom 10% of firms, firms belonging to the *Business Review Weekly* (BRW) Top 1000 firms, and the top 10% of firms.

Table 7 shows the results of the analysis. The unshaded areas show that the role of education and its impact on management practices are significant, whereas the grey areas show where findings are not significant. The results can be summarised as follows:

- ✧ Firms in the bottom 10% of the overall management score range had management scores statistically lower than the rest of the cohort across all the management areas. These firms had managers and non-managers with university degrees at 24.27% and 2.95% respectively, which is statistically significantly lower compared with the education levels seen among the rest of firms in the sample.
- ✧ For managers among the bottom 10% of firms, their education level is statistically linked to better management practices across all areas except performance management, where the relationship is not statistically significant. However, the proportion of variability across all management scores, as explained by non-managers with a degree, not only became small but also insignificant.
- ✧ Firms in our sample that are featured in the 2008 BRW Top 1000 list perform impressively and score significantly higher in all areas of management practices than the rest of the firms.
- ✧ The BRW Top 1000 firms tend to have a significantly higher proportion of both managers and non-managers with a university degree compared with the remaining firms, and the difference is indeed statistically significant at 54.8% and 13.32%, respectively.
- ✧ For the BRW firms, the proportion of variability in management scores, as explained by managers and non-managers with a degree, was found to be important and significant in all areas, except for non-managers with a degree, in the area of people management.
- ✧ Firms that were amongst the top 10% in terms of their overall management practices score performed statistically significantly better across all areas of management compared with the rest of the cohort.
- ✧ Among the top 10% of performing firms, the percentage of managers and non-managers with degrees was also significantly higher at 60.16% and 14.36% respectively.
- ✧ For the top 10% of performers, the relationship between the level of education among managers and people management is insignificant. However, the proportion of variability in management scores for overall management score, operations and performance management, as explained by managers with a degree, remained significant; this confirms that investment in education and skills development is one of the key forces behind firm success.
- ✧ Similarly, the proportion of variability in management scores for operations, performance and people management for top performers, as explained by non-managers, was found to be insignificant; however, the proportion of variability in overall management score, as explained by non-managers with degrees, remained significant, indicating that, at that high level of firm performance, irrespective of the individual components of management practices, the overall contribution made by educated non-managers in executing management practices is still very important.

Table 7 Sub-group based on management practices score

	Bottom 10% vs rest of the cohort				BRW firms vs rest of the cohort				Top 10% firms vs rest of the cohort			
	Bottom 10%		Rest of the cohort		BRW firms		Rest of the cohort		Top 10% firms		Rest of the cohort	
	Mgmt score	R ² value – proportion of variability explained by managers with a degree	Mgmt score	R ² value – proportion of variability explained by managers with a degree	Mgmt score	R ² value – proportion of variability explained by managers with a degree	Mgmt score	R ² value – proportion of variability explained by managers with a degree	Mgmt score	R ² value – proportion of variability explained by managers with a degree	Mgmt score	R ² value – proportion of variability explained by managers with a degree
Overall mgmt	1.96	21.22(s)	3.11	4.98(s)	3.22	15.6(s)	2.92	6.84(s)	3.96	10.6(s)	2.86	7.55(s)
Ops mgmt	2.08	9.22(s)	3.36	4.62(s)	3.47	10.33(s)	3.16	6.40(s)	4.28	4.909(s)	3.1	6.70(s)
Perf. mgmt	1.78	2.32(ns)	3.11	4.72(s)	3.29	21.75(s)	2.88	6.21(s)	4.05	10.48(s)	2.84	6.07(s)
People mgmt	1.97	11.56(s)	2.81	1.40(s)	2.86	4.79(s)	2.67	3.21(s)	3.52	0.46(ns)	2.62	3.13(s)
<p>Managers with degree significantly lower in bottom 10%: 24.27 vs 46.42%</p> <p>Managers with degree significantly higher in BRW: 54.8 vs 40.9%</p> <p>Managers with degree significantly higher in top 10%: 60.16 vs 42.02%</p> <p>Non-managers with degree significantly lower in bottom 10%: 2.95 vs 9.04%</p> <p>Non-managers degree significantly higher in BRW : 13.32 vs 7.03%</p> <p>Non-managers with degree significantly higher in top 10%: 14.36 vs 7.65%</p>												

In summary, the analysis above reinforces the importance of education and skills and highlights their impact on management practices and its dimensions—overall, operations, performance and people management. High-performing companies therefore hire workers with superior skills—both ‘soft’ generic skills, as well as ‘hard’ technical skills. What seems interesting is that firms at the lower end—based on low performance or based on small firm size—are constrained by the limited human capital resources they possess. It is likely that they are not performing well enough because they lack a skilled and educated workforce, or that firms are selective in their recruitment, based on need, with the latter perhaps affecting the firm’s ultimate performance. On the other hand, the top-performing firms and larger-sized firms have higher numbers of both managers and non-managers with a university degree, which is markedly important for firm performance.

Management practice—its association with innovation and productivity

In the context of a world of finite resources, it is important to recognise that innovation can increase productive capacity and promote growth. Accordingly, innovation is defined in the Oslo Manual as:

The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations. (OECD 2005, p.46)

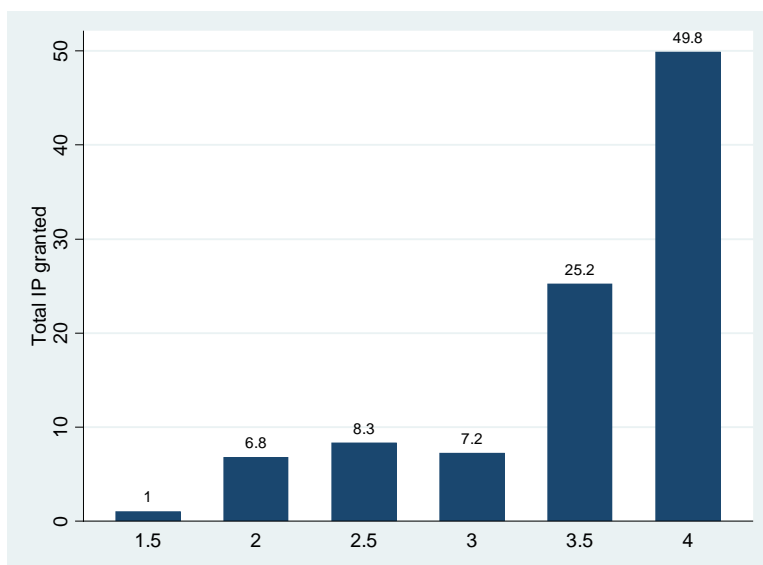
In other words, innovation involves changes to a firm’s products, services, production processes and organisational structure that are designed to bring a new or improved good or service to market. However, at the level of the individual firm, most innovation is incremental—adopting and adapting established good management practices rather than introducing ‘new to the world’ changes. The cumulative effect of these often small improvements over time is, however, profound. Effecting these improvements invariably involves the workforce acquiring new skills and knowledge through on-the-job training, formal training or learning-by-doing strategies.

According to the World Economic Forum (Porter & Schwab 2008), Australia is among those countries that have reached ‘the innovation-driven stage’ (p.7) of development; that is, ‘companies must compete through innovation ... producing new and different goods using the most sophisticated production processes’ (p.7). It is only through the pursuit of ongoing innovation that Australia can maintain its high wages and living standards. Accordingly, the Australian Government’s efforts in this area should explicitly incorporate support for management and leadership development into its productivity agenda.

In the past a number of research studies have been conducted to identify where Australia stands in the area of innovation. A global study conducted by Droege and Company (1999) to assess the barriers to the path of innovation across the world showed that Australian managers lagged behind their counterparts in the US, Europe and Asia in relation to the adoption of innovation strategies and processes. A more recent research study by the Australian Business Foundation also indicated that Australian managers lacked the capability for strategic response, entrepreneurialism, and a global business outlook (Roos, Fernstrom & Gupta 2005). In terms of innovating performance, one of the key results of this study was that Australia ranked poorly in management style and capability, and that Australian managers were ‘good at solving tactical and operational problems in a creative way, but lacked the ability to sustain innovation in a strategic way’ (Roos, Fernstrom & Gupta 2005, p.24).

We next study the impact of management practices on innovation, in which the number of innovation patents is used as an indicator of the intensity of innovation activities within firms (figure 7).

Figure 7 Management scores and level of innovation patents (IP)



Source: Green et al. (2009) dataset; IP Australia.

Regression analysis further explains that there is a statistically significant positive relationship between management score and innovation ($p < 0.05$), and that the proportion of variability in innovation can be explained by approximately 8% for both the overall management and people management scores, respectively (table 8). Both of these findings indicate that well-managed firms appear to be more innovative, as the highest-scoring firms have the maximum number of innovation patents granted.

Table 8 Proportion of variability in innovation as explained by management score

	R² value – proportion of variability in innovation explained by management score
People management score	8.18 (significant at 10%)
Overall management score	8.07 (significant at 10%)

Source: Green et al. (2009) dataset.

Having examined external validity between management practices and innovation, we now look at the association between management practices and productivity. According to the Australian Management Practices research study, the quality of management practices has a measurable impact on labour productivity, as well as on sales and the number of employees in firms (as shown by columns (1), (2) and (3) respectively in table 9):

A single point increase in the management score – a measurement derived from the 18 management characteristics in our scoring grid – is associated with an increase in output equivalent to a 56% increase in the labour force or a 44% increase in invested capital.

(Green et al. 2009, p.6)

Additional econometric analysis was conducted using the people management score on labour productivity and firm performance, and this relationship was found to be positive and significant. In this analysis labour productivity was measured as $\ln(\text{sales}/\text{employees})$, sales, and number of employees (as shown by columns (1a), (2a) and (3a) respectively in table 9), the same as was done for the overall management practices score. There were no other associations found with any other measures of labour productivity or firm performance. Consequently, we can conclude that both overall management practices as well as people management are important, and that high-performing management is a key driver in the promotion of more innovative and productive outcomes.

Table 9 Econometric analysis of firm performance

Model	(1)	(2)	(3)	(1a)	(2a)	(3a)
Dependent variable	Labour productivity <i>Ln(sales/employees)</i>	Sales <i>Ln(sales)</i>	Number of employees <i>Ln(labour)</i>	Labour productivity <i>Ln(sales/employees)</i>	Sales <i>Ln(sales)</i>	Number of employees <i>Ln(labour)</i>
Management Z score	0.084 (0.044)	0.130 (0.005)	0.195 (0.012)			
People management Z score				0.088 (0.026)	0.126 (0.004)	0.195 (0.007)
Ln (capital per employee)	0.085 (0.002)			0.073 (0.007)		
Ln (COGS per employee)	0.764 (0.000)			0.774 (0.000)		
Ln (labour)		0.107 (0.119)			0.109 (0.091)	
Ln (capital)		0.109 (0.000)			0.093 (0.002)	
Ln (COGS)		0.733 (0.000)			0.746 (0.000)	
Firms	68	68	371	68	68	371
Observations	126	126	1511	126	126	1511

Note: All columns estimated by OLS (ordinary least squares) with the p values in parentheses under coefficient estimates (the p values are estimated using standard errors that are clustered by firm). The sample includes all firms with available accounts data 2004–08. ‘Labour’ is the number of employees. ‘Capital’ is the book value of all property, plant and equipment (fixed assets) from the firm’s balance sheet. ‘COGS’ is the cost of goods sold from the firm’s income statement, where disclosed. Region, industry and general controls were applied. ‘Management Z score and People Management Z score’ is the firm-level score, standardised to a Z score.

There is no doubt that the attention of enterprises needs increasingly to move towards inculcating and fostering innovation and management capability, including people management, given their critical role in driving competitiveness and growth in the modern economy. The significant policy emphasis on enterprise-level innovation in the White Paper, *Powering ideas*, recognises the importance of management skills and talent:

Making innovation work requires a workforce with sophisticated skills of all kinds – including leadership and management skills. It also requires cooperative workplaces in which creativity is encouraged. Few organisations command all the skills needed to innovate successfully on their own. They must network and collaborate – locally and globally.

(Commonwealth of Australia 2009, p.17)

Conclusion

Our research concludes that investing in education and fostering skill development at management levels and in the general workforce should be a high priority, particularly in manufacturing firms. The findings suggest that in a majority of cases higher skill levels are positively and significantly associated with better management—where university education proxies as an indicator of skills in the area of developing and deploying superior management practices. Hence, engaging better educated personnel both as managers and shopfloor workers, as well as ensuring that their skills are constantly upgraded through training and development initiatives, will contribute to enhanced management performance within firms.

The key implications of the study for the VET sector is the need to develop management and leadership skills at every level of the workplace, with an emphasis on building structured, team-

based innovation capability across firms and organisations. This is not just a matter of acquiring qualifications, although in this regard the study indicated a positive association, but developing the knowledge and skills that the qualifications represent. Some attention has been given to this challenge by VET research and curriculum bodies such as Innovation and Business Skills Australia (IBSA), and it has also been taken up recently by Skills Australia (2010), but a broader understanding of the issues will be required for successful implementation of this approach.

Firms develop absorptive capacity as a result of their own knowledge base gained through previous learning exposures and education—doing-by-learning—and also as a by-product of intense activity in the workplace—learning-by-doing. Investing in education is a solution for the future: skills and capabilities are needed to perform managerial roles effectively, and the extent to which they can be acquired through the education system (future managers) and in firms (existing managers) is critical to unlocking productivity and transforming the working lives of people.

Further, a management focus has the potential to drive innovation and productive outcomes in the economy, a premise confirmed by our research findings. Australia has some way to go towards closing the gap with the global best countries in the field of management capability and performance. The leading performers in this area demonstrate that innovation incorporates not only technology and product-related improvements, but also improvements in managerial innovation, which in turn have the potential to translate into non-technological innovation outcomes. In this context, the efforts of the Australian Government in explicitly incorporating management capabilities into its innovation system are paramount. Finally, enhancing Australia's innovation system through a focus on management education and skills and programs to support organisational change and improvement is a cost-effective way to restoring momentum to Australia's productivity performance.

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Appendix A: The 18 dimensions of management practices

Operations management

Adoption of Lean manufacturing

Best practice: All major aspects of Lean have been implemented

Worst practice: Other than just-in-time, no other aspects of Lean manufacturing have been introduced

Rationale for the adoption

Best practice: Lean manufacturing was introduced to meet business objectives

Worst practice: Lean manufacturing was introduced to catch up to competitors

Process problem documentation

Best practice: Exposing problems is integral to individuals' responsibilities rather than ad hoc solutions

Worst practice: No process improvements are made when problems occur

Operations performance tracking

Best practice: Performance is continuously tracked and communicated to all staff using a range of visual tools

Worst practice: Tracking is ad hoc, and measures being tracked do not indicate directly if overall business objectives are being met

Operations performance review

Best practice: Performance is continuously reviewed, based on indicators tracked; follow-up ensures continuous improvement

Worst practice: Performance is reviewed infrequently and only success or failure is noted

Operations performance dialogue

Best practice: Regular performance conversations focus on addressing root causes. Purpose, agenda, and follow-up steps are clear to all

Worst practice: Relevant data are often not present at meetings or discussion is based on data that is not meaningful. Agenda and purpose are not clear

Consequence management

Best practice: Failure to achieve agreed targets drives retraining or moving individuals around

Worst practice: Failure to achieve agreed targets does not carry any consequences

Performance management

Types of goals

Best practice: Goals are a balance of financial and non-financial goals

Worst practice: Goals are exclusively financial or operational

Interconnection of goals

Best practice: Corporate goals increase in specificity as they cascade through the business units

Worst practice: Individual workers are not aware of how their contribution is linked to corporate goals

Time horizon

Best practice: Short-term goals are set so that they become a staircase to reach the long-term goals

Worst practice: Top management's main focus is on short-term goals

Setting stretch goals

Best practice: Goals are demanding for all divisions, and are grounded in solid economic rationale

Worst practice: Goals are either too easy or impossible to achieve

Clarity of goals

Best practice: Performance measures are well defined and well communicated;

worker performance is made public to induce competition

Worst practice: Performance measures are complex and not clearly understood; worker performance is not made public

People management

Instilling a talent mindset

Best practice: Senior managers are evaluated and held accountable on the strength of the talent pool they actively build

Worst practice: Senior management does not communicate that attracting, retaining, and developing talent is a top priority

Rewarding top performance

Best practice: The firm provides ambitious stretch targets with clear performance-related accountability and rewards

Worst practice: People within the firm are rewarded equally irrespective of performance level

Addressing poor performance

Best practice: Poor performers are moved to less critical roles or out of the company as soon as weaknesses are identified

Worst practice: Poor performers are rarely removed from their positions

Promoting high performers

Best practice: Top performers are actively identified, developed, and promoted

Worst practice: People are promoted primarily upon the basis of tenure

Attracting high performers

Best practice: The firm provides a unique value proposition to encourage talented people to join the company instead of the competitors

Worst practice: Competitors offer stronger reasons for talented people to join their companies

Retaining high performers

Best practice: Managers do whatever it takes to retain top talent

Worst practice: Managers do little to try and keep the top talent

Additional question

Education and skill levels of managers/non-managers

Proportion of employees with a university/tertiary degree

Source: Bloom & Van Reenen (2007, pp.1389–96).

Building innovation capacity: the role of human capital formation in enterprises

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There are a number of factors that affect enterprises' ability to innovate. These include internal factors such as the ability to detect technological changes in the environment, the development of core competencies from which innovation can develop, and external factors such as the maturity of the market the enterprise serves and the impact of government policy on stimulating innovation. A range of studies have suggested that human factors within the enterprise are critical to innovation. However, these studies have not established exactly how human factors in enterprises improve the ability of enterprises to innovate. Direct links between human resource management (HRM) practices and learning and development practices and innovation performance at the enterprise level have been difficult to establish. We propose that the links between HRM and learning and development practices and innovation is a two-stage process. That is, HRM and learning and development practices contribute to the development of enterprise capacity to innovate. It is the development of innovation capacity that leads ultimately to improvements in enterprise innovation performance.

Introduction

Despite all that has been written on the importance of human capital factors in innovation, most of the research literature is prescriptive. The dilemma is that humans in their daily activity are creatures of habit and routine, yet innovation requires recognition and responsiveness to change. Oakley (2002, p.31, fn.4) notes that '... the agents and strategic actions in focus ... are confronted with the problem of adapting habits and routines in order to make decisions in the face of novel situations'.

'Innovation can be defined as the creative application of knowledge to increase the set of techniques and products commercially available in the economy' (Courvisanos 2007, p.46). Harnessing this process for business enterprises and economic development requires an appreciation of the factors that produce knowledge and creativity. Innovation has long been regarded as essential for enterprises and national economies to thrive in globalised and increasingly competitive markets (Christensen & Raynor 2003; Department of Trade and Industry [UK] 2003). However, the historically poor innovation performance of Australia in relation to other developed

economies has concentrated the efforts of Australian researchers and policy-makers to address this issue. In this context, in 2008 the Rudd Labor Government made innovation a policy priority early on, with the creation of the Department of Innovation, Science and Research and the commissioning of the Cutler Review of Australia's innovation performance (Cutler 2008). Before the full extent of the Global Financial Crisis was realised, the Cutler Review made the strong argument that Australia's innovation performance was poor by international standards and that there was a key role for government policy in promoting innovation in enterprises. Since the Cutler Review, the global economic downturn has served to emphasise the need for Australian industry to become more innovative to enable the country to meet the twin global challenges of shifting from debt-driven consumerism and high-carbon emissions production into sustainable development (Stiglitz 2010). Australia is still economically too trade-dependent on a few large industries which are vulnerable to both the vagaries of the international economy (especially commodities, tourism and education) and the international pressures for ecological sustainability. The need to diversify in order to ameliorate any future economic volatility and environmental destruction places enormous pressure on Australia's innovation processes. This includes the three major types of innovation—product (new goods and services), process (new ways of doing things) and organisational (new and more productive ways of organising work in order to support product and process innovation).

There are many factors that affect enterprises' ability to innovate. These include internal factors such as the technical skills for developing successful in-house R&D outcomes, the ability to detect technological changes in the environment, and the development of core competencies from which innovation can develop. External factors are not dependent on the enterprise, but instead on the life cycle position of the market which the enterprise serves, the impact of government policies to stimulate innovation, and the nature of the innovation systems that feed into the national and regional business activity. There is a significant body of research on the technological factors of innovation and how to manage these factors to better stimulate innovation in enterprises (see Ahamed & Lawrence 2005). Only since the early 1980s with the work of the Harvard Business School (notably, Kanter 1983)—rediscovering the path-breaking book by Penrose (1959)—has the role of human capital factors in inducing innovation been specifically identified. The focus of this chapter is on the role of these human capital formation factors in the management of innovation.

Several studies have suggested that human factors within the enterprise are critical to innovation (Kanter 1983; Gupta & Singhal 1993; Hauser 1998). Thus, the ability of enterprises to innovate depends on the effective management of human resources and, in particular, the learning and development (L&D) practices instituted by enterprises that increase both the quantity and quality of workforce innovation skills. It should be noted that the education system (from primary to secondary and then on to tertiary education) underpins any enterprise L&D system. Studies in Denmark (Laursen & Foss 2003) and Spain (Jiménez-Jiménez & Sanz-Valle 2008) show that better human resource management practices and the establishment of new L&D systems increase enterprise innovation. However, these studies have not established a theoretical structure or exactly specified the broad human capital formation practices that enterprises need to put in place to improve their 'innovation capacity'.

Building innovation capacity: a macro framework

Innovation capacity is the ability of enterprises to identify trends and new technologies, as well as acquire and exploit this knowledge and information (Tidd, Bessant & Pavitt 2005). This innovation 'capacity' concept needs to be clearly distinguished from dynamic innovation 'capability'; the latter deals with the firm's specific ability to continuously transform knowledge and ideas into profitable innovations. In this context, Terziovski (2007) developed a leadership-based model, in which firms innovate across three domains—new product development, sustainable development and e-commerce—using all aspects of the firm's capacities, including HRM. This current investigation examines the *prior* role for employees, through the HRM function, to acquire capacity

to innovate in order to then be capable of working within a strategic innovation model of the type set up by Terziovski.

The process-based conception of innovation (or absorptive) capacity, linking technological and human capital stimuli, highlights the role of learning in the innovation process (Lichtenthaler 2009). For a long time innovation research concentrated on the technological factors that enhanced innovation, identifying all the 'hard' elements of the innovation process, such as R&D, physical sciences education, engineering and design (see Tidd, Bessant & Pavitt 2005, p.112). As studies on the human factors of innovation within the enterprise began to appear after Kanter (1983), the need arose to link these human factors into an overall macro-perspective of the complete innovation process that operates within an enterprise. Figure 1 presents this macro framework, based on the research literature on innovation in business enterprises.

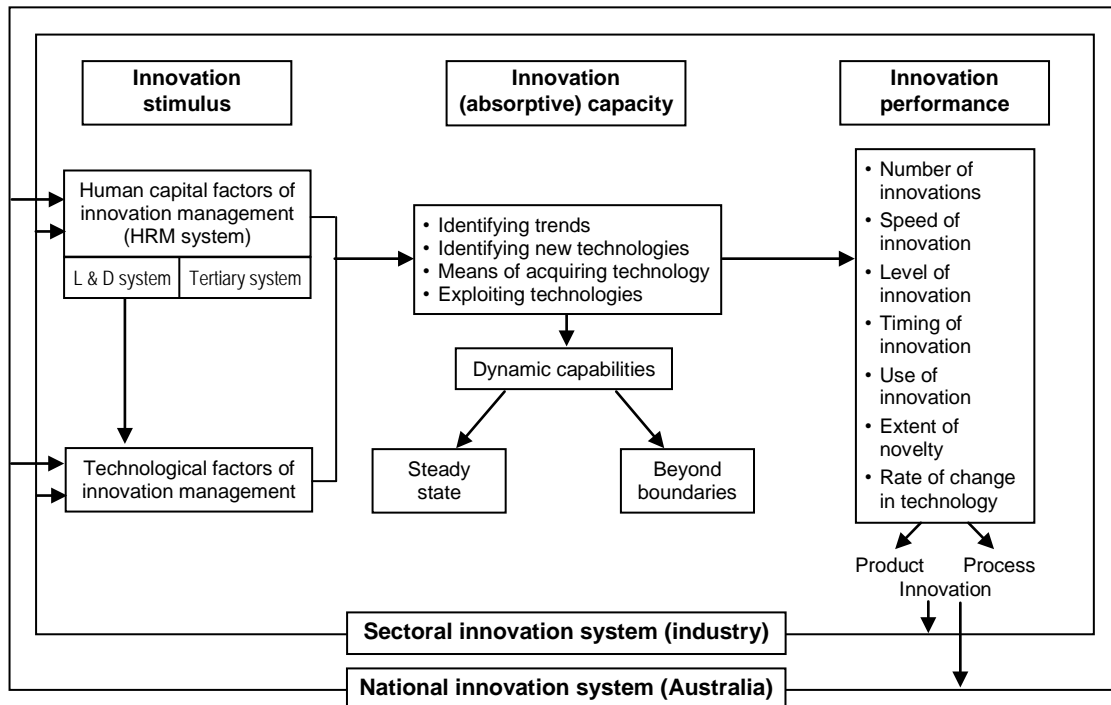
In figure 1, the human capital factors are underpinned by the internal L&D system within an enterprise and the external tertiary (vocational education and training and higher education) education system, which supports internal L&D. The L&D system can be defined as a systematic arrangement that enables the effective absorption of information, knowledge and ideas within a specified organisational structure. Such a system brings together internal and external training, individual career development and organisational development to embed in employees a learnt ability to recognise and use stimuli, thus building innovative capacity. An emerging small range of literature is examining the new forms of L&D in Australia that are needed to support innovation-based learning enterprises. Another set of studies undertaken for NCVET have focused on the role of the external VET system in working with innovative enterprises to improve their abilities to implement product, process and organisational innovation—usually by supplying skills at the intermediate level (Dawe 2004; Curtain 2004; Garlick, Taylor & Plummer 2007). There have also been some studies in Australia on the role of universities in supporting innovative entrepreneurship and business development (Garlick 1998). However, these studies usually examine how the public tertiary system can support the L&D systems of enterprises, rather than what the enterprises can do to develop their L&D systems. The principal focus of this study is to look inside enterprises and examine their specific L&D systems, the tertiary education system that supports L&D, and their interaction with the HRM systems and practices of enterprises. A combination of these three systems delivers the complete human capital formation factors applying to enterprises, which are the basis for building innovation capacity, and no Australian study has examined the interaction of these three systems for this purpose.

Figure 1 is a development of the macro framework in Prajogo and Ahmed (2006), known as the Stimulus-Capacity-Performance (SCP) approach. In the framework, human capital and technological capital are the stimulus factors that develop innovation capacity. In this study we use the term 'stimulus factor' to mean causal factors or drivers of innovation. It is this innovation capacity that determines how effectively an enterprise can undertake the innovation commercialisation process, from imagining and incubating, to demonstrating, promoting and sustaining (Jolly 1997). The better built the innovation capacity, the more effectively an enterprise can conduct this innovation process, and thus, the stronger the innovation performance.

Both Prajogo and Ahmed (2006) and Jiménez-Jiménez and Sanz-Valle (2008) explain how empirical research does not show that innovation stimulus factors have any direct effect on innovation performance. Instead, both studies demonstrate that there is a link between the stimulus factors implemented at the enterprise level and the development of the 'innovation capacity' of the enterprise. Specifically, innovation capacity is the potential of the enterprise to innovate, based on the capabilities of its employees to recognise, assimilate and apply innovation stimuli (Prajogo & Ahmed 2006, p.502). This innovation capacity perspective was first labelled 'absorptive capacity' by Cohen and Levinthal (1989), in recognition of the need for workers in the enterprise to absorb information and knowledge from external collaborations in R&D. Michie and Sheehan (1999) extend this absorptive capacity concept to the organisational setting in which employees operate

and to their ability to absorb innovation stimuli within the enterprise. Thus, it is the extent to which all the innovation stimuli (both technological and human) are able to be absorbed within the enterprise over time (that is, dynamic) that provides the capabilities for innovative performance. Tidd, Bessant and Pavitt (2005, p.73) identify two dynamic capabilities—*steady state* (or ‘doing what we do but better’) and *beyond boundaries* (or ‘doing differently’). Steady state works on a step-by-step (or continuous) process of incremental innovation, while beyond boundaries operates at a discontinuous level that drives radical innovation. Building innovation capacity across both capabilities enables enterprises to become ambidextrous in functioning on both incremental and radical innovation at the same time.

Figure 1 Macro-level innovation framework



Source: Smith et al. (2010).

Many studies support the macro framework of managing both human and technological capital formation to build innovation capacity, and also that such capacity building leads directly to stronger innovation performance.¹ Major books on building innovative organisations, for example, Dussauge, Hart and Ramanantsoa (1992) and Christiansen (2000), highlight the need to integrate the ‘soft’ human factors into technology management in order to deliver effective innovation performance from enterprises, which is measured by the various dynamic variables specified on the right-hand side of the framework in figure 1.

Prajogo and Ahmed (2006) identify four human capital innovation stimulus factors: leadership, people management, knowledge management and creativity management. Leadership sets the scene in determining the direction the enterprise’s HRM system will take, in that highly transformational leadership will create a more innovative business climate than highly transactional leadership. Our model builds on this work but extends the framework to include the more recent work on high performance work systems which emphasises the importance of bundling management practices rather than focusing on the impact of individual practices. Our framework also does not focus on leadership; from the HRM systems perspective, the ‘leadership’ factor is not a human capital

¹ Examples of such studies are Schroeder, Scudder and Elm (1989), Vrakking (1990), Brown and Karagozoglu (1993), Zien and Buckler (1997), Tang (1998), Ahmed (1998).

formation tool that can be implemented to build innovation capacity. The concept of building capacity in the enterprise's workforce is as critical to successful innovation as acquiring technological knowledge and capital. To this end, the macro framework of innovation outlined in figure 1 identifies the technological and human innovation stimuli that are needed to build innovation (or absorptive) capacity. It is this capacity that enables the innovation process to traverse effectively through its stages to deliver a measurable innovation performance in product and process innovation.

Modern approaches to HRM

Human resource management has become a touchstone of modern management practice. As the global economy became increasingly competitive in the 1980s (Best 1990), enterprises started to look to the skills and abilities of their employees as sources of future competitive advantage (Barney 1991). The example of Japan's economic success in the 1980s was a powerful indicator to business leaders in the developed world that competitive success could be gained, at least partly, through better ways of managing employees. From this emerged the recognition that HRM is essential to creating an organisational climate or culture in which employees' skills and abilities can be effectively utilised for building innovation capacity. This basic recognition led to the development of two strategic models of HRM in the research literature.

One set of strategic models of HRM emphasises the importance of training employees well at work in order to secure their commitment to the enterprise and thus better business outcomes (Beer et al. 1984; Walton 1985; Rainbird 1994). These models are known as 'soft' models of HRM, as they emphasise universal and prescriptive ways of managing employees that yield the desired outcomes for enterprises. Walton (1985) summarises this soft approach as moving '... from control to commitment'. Walton's thesis is that, through better HRM practices such as careful selection and recruitment, performance management, rewards and training, enterprises could move away from an emphasis on controlling their employees to a situation in which enterprises gave employees more control and allowed them to make a greater commitment and contribution to the enterprise. This is the first place that a link to innovation can be drawn. Guest's normative (1987) model sets out the concept of better HRM practices for better outcomes in the enterprise (figure 2). Thus, HRM practices become linked to better human resource outcomes, including commitment and flexibility. Such new practices yield organisational outcomes, including better job performance, lower turnover, and also higher levels of innovation.

Figure 2 A theory of HRM

HRM policies	Human resource outcomes	Organisational outcomes
Organisation/job design		High Job performance
Management of change	Strategic integration	High Problem-solving Change Innovation
Recruitment selection/ socialisation	Commitment	
Appraisal, training, development	Flexibility/adaptability	High Cost-effectiveness
Reward systems		
Communication	Quality	Low Turnover Absence Grievances

Source: Guest (1987).

The other set of strategic HRM models link HRM directly to business strategy. This strategic approach is known as the 'hard' approach to HRM, in contrast to the soft approach (Fombrun, Tichy & Devanna 1984; Legge 1995). In the hard approach, the role of HRM is to enable the core business strategy of the enterprise to be implemented effectively. This approach places less emphasis on the treatment of employees at work and the securing of employee commitment, but rather on treating employees as another—albeit critical—strategic resource for the enterprise on which competitive advantage could be built. This brings HRM into the strategy-formulation processes of the enterprise. It also means that, unlike the soft approach with its emphasis on the universal prescription of 'better ways of managing', the hard approach is contingent on the circumstances of the enterprise. Schuler and Jackson (1987) show how different HRM strategies might be lined up with different business strategies. Using Porter 1980s' characterisation of the three basic business strategies of innovation, quality enhancement and cost-reduction, Schuler and Jackson show that each strategy requires different HRM practices.

The idea of an HRM strategy being contingent on the business strategy and the commercial circumstances of the enterprise led to the notion of 'fit'. Here, HRM has to fit both the external, strategic posture of the enterprise and display internal organisational structural fit. The aim is for work to be designed to ensure that innovation occurs within an external strategic setting designated by the enterprise (external fit), while ensuring that individuals in the enterprise are allowed to innovate (internal fit). If successful, such an approach allows for building an ambidextrous innovative capacity, as argued by Tidd, Bessant and Pavitt (2005). Further, the notion of internal fit means HRM practices have to fit together to ensure that one practice does not invalidate another practice (Baird & Meshoulam 1988). Thus, HRM practices need to work together in self-reinforcing 'bundles' in order to provide maximum benefit to the enterprise (MacDuffie 1995), both for the strategic posture of the enterprise and for maximising internal creative activities.

The notion of bundling HRM practices has become very influential in formulating the current role of HRM in enterprises. Using the work of Edith Penrose, who examined the way in which enterprises compete in terms of resources (1959), the resource-based view (RBV) of the enterprise builds on the notion of human resource 'bundles' to show that employees and their skills are the only real source of sustainable competitive advantage, when other resources such as technology are easily imitated by competitors. Hamel and Prahalad (1994) describe this as a core competence for enterprises. Thus, the resource-based approach to HRM emphasises the creation of unique dynamic bundles of capabilities based on the skills and attitudes of employees (Boxall & Purcell 2008). The role of HRM is to nurture the human resource and to ensure that enterprises hold onto employees in order to build a bundle of dynamic capabilities that create sustainable competitive advantage for both steady-state and beyond-boundaries innovation.

More recently, attention in HRM research has switched from strategy towards the concept of 'high performance work' systems (for example, Colombo, Delmastro & Rabbiosi 2007). The emphasis on work systems as opposed to simpler HRM practices also emerged from the success of Japan in the 1980s, in this case, from the development of the Toyota Production System, which was held responsible for the remarkable levels of productivity achieved by Toyota and other Japanese manufactures in the 1990s (Womack, Jones & Roos 1990). High performance work systems blend HRM practices, work design and the use of new technology. As Bélanger (2004) put it, high performance work systems embrace three concepts: production management (greater use of flexible quality production systems); work organisation (production processes based on knowledge, cognition and teamwork); and employee relations (harnessing employee commitment). Usually in these high performance work systems the human resource manager will be given the task of implementing a performance-based pay system and ways of deploying the tacit skills of the workers.

The role of HRM in innovation

There is very little empirical research that attempts to forge the links between HRM and innovation at the enterprise level. The research that has focused on this aspect sees HRM as a tool for managing innovation, rather than focusing on the role of HRM in promoting innovation (Becker & Matthews 2008; Birkinshaw, Hamel & Mol 2008). Many of the studies undertaken by innovation scholars focus on innovation capability and its propensity to generate innovation performance, but do not focus specifically on the role of HRM in building innovation capacity. This restricted view exists despite deep research on the strategic position of HRM in enterprises. An integrated framework bringing together the work of HRM and innovation scholars is only beginning to emerge (see for example, de Leede & Looise 2005).

Studies by HRM scholars have attempted to map innovation performance against HRM practices. Jiménez-Jiménez and Sanz-Valle's (2005) empirical study of a range of Spanish enterprises examines how an enterprise configures an HRM strategy for innovation performance. This study is based on both the Schuler and Jackson (1987) categorisation of HRM strategy and Porter's (1980) strategic types, and on the widely used Miles and Snow taxonomy of strategy (1984). These latter two 1980s studies represent opposites in the use of HRM to promote innovation. While Schuler and Jackson advocate a range of inclusive 'soft' HRM practices, Miles and Snow prefer a model that is much 'harder' in its orientation—hiring in the skills that are required, with little internal promotion and limited training programs. In a study of 350 Spanish firms, Jiménez-Jiménez and Sanz-Valle (2005) found that the Schuler and Jackson model appears to result in higher levels of innovation performance amongst the firms in the sample. This finding confirms the importance of the strategic approach to HRM and innovation, and also the use of 'soft' HRM practices to create a stable and committed workforce willing to take risks (and learn from them) to further innovation.

Another empirical study of Spanish firms by Perdomo-Ortiz, González-Benito and Galende (2009) examines the use of HRM practices in association with total quality management (TQM), called 'HRMtqm practices', and their impact on innovation performance of enterprises. These include teamworking, extensive employee training, performance management and measures to increase the motivation of employees. In particular, the authors look at the use of these practices in bundles. HRMtqm practices are very similar in nature to those associated with high performance work systems, so the study presents a useful proxy for the impact of high performance work systems on innovation performance. The authors find a direct link between the use of bundles in high performance work systems practices and innovation performance. The strongest links in the study are between the use of teamwork (work organisation) and measures to increase worker motivation. There is also a weaker, direct link between the use of training and innovation (an issue discussed in more detail below).

As noted at the beginning of this chapter, there are studies which argue that the link between HRM and innovation performance is not direct, but mediated through the creation of an organisational 'capacity', leading to innovation capability, which is in turn associated strongly with actual innovation performance. Lau and Ngo's (2004) study of Hong Kong firms is typical of these studies. Lau and Ngo examine the impact of specific HRM practices—training, team development and performance-related pay. They theorise the existence of a developmental culture that leads to higher levels of innovation performance. Lau and Ngo note only training as being linked directly to innovation performance and that this relationship is rather weak, and conclude that HRM practices strongly link to the creation of a developmental culture in enterprises. In essence, a developmental culture is an organisational culture in which individual development is encouraged and rewarded. Prajogo and Ahmed (2006) support this indirect view, establishing that the capacity for managing sophisticated technological and R&D knowledge from inside or outside the enterprise is the specific culture that induces innovative performance.

Possibly the most comprehensive work on HRM and innovation has been undertaken in Denmark. Since the mid-1990s, the University of Aalborg has hosted the Danish Innovation System project (DISKO), which involves a regular survey of Danish private sector enterprises that aims to trace the relationship between technical and organisational innovation at the enterprise level. Laursen and Foss (2003) analyse the 1996 dataset from the project to explore the links between innovation and HRM. This study links the level of enterprise innovation to the extent to which enterprises bundle their HRM and high performance work systems practices, reflecting the importance of the bundling theory of high performance work systems, as discussed above. Laursen and Foss find a strong relationship between enterprise-level innovation and two forms of the bundling of HRM and high performance work systems practices. The first bundled system consists of interdisciplinary workgroups, quality circles, employee suggestion schemes, planned job rotation, delegation of responsibility, integration of functions, and performance-based pay. The second bundled system relates to training, discussed below. Thus, the study shows that HRM practices, when implemented together in a bundled fashion, have a strong stimulus effect on innovation in the sample manufacturing firms. The Danish research establishes that it is bundles of HRM practices that are linked to innovation performance rather than individual practices.

Thus, research strongly suggests that HRM and innovation are linked more effectively by an inclusive ‘soft’ bundle of HRM practices, and that such bundles create a culture or set of dynamic capabilities from which both steady-state and beyond-boundaries innovation spring, rather than enhancing innovation performance directly.

The research project

In 2009, the National Centre for Vocational Education Research funded our project to investigate the links between better human resource management practices and innovation in enterprises. The aim of the research was to elaborate a theory of human capital formation in enterprises that built innovative capacity and elicited the actual human resource management practices that build this capacity. The project research questions were as follows:

- ✧ What is the role of human capital formation through human resource management and learning and development practices in enterprises that promote/inhibit the development of innovative capacity?
- ✧ What part does enterprise engagement with the tertiary system, both VET and higher education, play in the formation of human capital and the development of innovative capacity?
- ✧ What guidelines can be developed that can be used by managers in enterprises to promote innovative capacity through better human capital formation?
- ✧ What role is there for intermediary bodies, particularly industry skills councils, in developing innovative capacity in their industry sectors?

Survey methodology

The project methodology involved three phases. The first phase was a series of interviews with experts; this helped frame questions for the national employer survey, which constituted the second phase of the research. The third phase involves a series of case studies. This chapter reports results from the employer survey.

The survey covered six main topic areas, consistent with the conceptual framework presented in figures 1 and 2: organisational characteristics; innovation practices and strategies; human resource practices; learning and development practices; human resource performance; and organisational context. The survey also tested for the linkages that organisations enjoyed with external bodies—particularly educational institutions. Development of the survey took place in late 2009 and early 2010. The target population for the survey were human resource managers in medium-to-large private enterprises (defined as those companies with 50 or more employees) across Australia. The

population was limited to private sector organisations with 200 or more employees. The estimated size of this population was 5876 companies. The sample frame for the study was drawn from the Dun and Bradstreet company database. A stratified sample of 1875 organisations was drawn from this sample frame for the purposes of the study.

Data collection for the survey was conducted via a paper-based self-completion survey, with return via pre-paid envelope. Three waves of mailouts were completed, in April, May and June 2010, to maximise response rates. The Centre for Regional Innovation and Competitiveness (CRIC) at the University of Ballarat managed the survey printing and mail distribution. Overall, 142 responses were returned. A further 313 distributed surveys were returned to CRIC marked 'return to sender', while there was no response from the remaining 1420 distributed surveys. Excluding the 'return to sender' returns, which were deemed to be out of sample, this results in a final response rate of 9.09%. While a low response rate presents some challenges to the interpretation of the survey data, response rates around 10% are not unusual in employer surveys. Response rates to employer surveys have been in decline for some time. Moreover, testing for non-response bias enabled the research team to feel confident that the survey returns were largely representative of the sample in terms of major characteristics.

Results from the survey

In terms of organisational characteristics, most of the organisations in the sample were large, with a median of 818 staff and a mean of 350. Most of the organisations were privately owned, with over 70% being private limited companies. Over 70% of the organisations were either Australian-owned or subsidiaries of an Australian parent company. The majority of organisations were involved in manufacturing, retail or construction.

Most of the organisations in the sample employed predominantly full-time, permanent staff. The use of part-time and casual staff was quite limited, with 90% of the organisations employing fewer than 17.5% of their workforce on a part-time basis and 75% of organisations employing fewer than 15% of staff casually. The level of tertiary qualifications held by staff in the sample organisations was relatively low. In 75% of the organisations fewer than 40% of staff held VET qualifications and, on average, only 10% of staff in the sample organisation held a higher education qualification.

Very few measures of human resource practices were related to innovation capacity or innovation performance directly. The only measures that showed a relationship to innovation were measures of work organisation and flexible work practices.

Few measures of training and development were related to innovation capacity or performance. The only measures that showed any relationship were the areas covered by training and company attitudes to training. The clustering of human resource management practices into high performance work patterns has long been associated with higher organisation performance on a range of measures. In terms of innovation, the study reveals that organisations tend to use one of three possible clusters of high performance work practices—flexible working time, team-based work organisation and a combination of a larger number of practices.

Relationships underlying the conceptual model

Having considered the various measures included in this study, the analysis now turns to an examination of the relationships underlying the conceptual model. In general, it would be preferable to consider each of these relationships within a single model, most often using techniques such as structural equation modelling. However, this was not possible, given the final sample size achieved in the survey. For this reason, each of the paths in the conceptual model will be addressed separately, and then implications drawn for the case studies that form the next phase of the project. The analysis is in three stages:

- ✧ the relationship between innovation capacity and innovation performance

- ✧ the relationship between innovation stimulus and innovation performance
- ✧ the relationship between innovation stimulus and innovation capacity.

This study examined both innovation capacity (the capability of an organisation to innovate) and innovation performance (the actual innovation activities of an organisation). Both of these aspects of innovation were measured using two dimensions—whether the innovation was associated with a process or product and whether the innovation was incremental or radical.

In terms of *process innovation*, the study showed clear relationships between innovation capacity and innovation performance. The results show that incremental process capacity is related to higher levels of process innovation performance, while a capacity for radical process innovation shows no apparent relationship.

By comparison, in terms of *product innovation*, higher process innovation performance is linked to radical product innovation performance. This suggests that process innovation appears to lead to product innovation in some cases. Product innovation capacity, whether radical or incremental, is also linked to higher levels of product innovation performance.

So, while the capacity of an organisation to innovate in terms of new products is linked to its performance in product innovation, there is no such clear relationship between process innovation and process innovation performance.

In testing for direct relationships between innovation stimuli and innovation performance, there were few direct relationships uncovered. The only stimulus factors that appeared to have a direct impact on innovation performance were measures of knowledge exchange and learning and development. None of the other stimulus factors had a direct impact on innovation performance.

The study examined the link between the major stimulus factors—human resource practices, knowledge management and creativity and innovation capacity. In terms of human resource management, separate HR practices such as work organisation and training activities were not linked to the development of innovation capacity, although positive attitudes to training demonstrated a link to product innovation capacity. The use of flexible work practices such as flexitime and working from home also showed a weak relationship to incremental product innovation capacity.

By comparison, there were some differences in innovation capacity associated with the bundling of human resource practices into high performance work clusters. In particular, the cluster of high training, high performance work organisation and flexible work practices showed a relationship to the development of innovation capacity.

Looking at other innovation stimuli, the major influence on innovation capacity was in the areas of external organisational linkages to support creativity and support for organisational learning and training within the organisation.

When all stimuli measures were concurrently analysed against innovation capacity, the predominant relationship with all four capacity measures was to external organisational linkages. High performance work organisation and knowledge exchange practices were also associated with incremental product innovation capacity.

The model of innovation performance that informed the research project argues for a staged model of performance—the development of innovation stimuli within the organisation to generate innovation capacity and leading to organisational innovation performance. The findings of the employer survey presented in this project support this model. The survey analysis examined the relationship of both innovation stimuli and innovation capacity factors to innovation performance, and demonstrated that there was no direct effect of innovation stimuli on

performance. By comparison, the innovation capacity factors indicated a clear relationship between capacity and performance.

The survey analysis then proceeded to explore the relationship between various innovation stimuli measures (people management, knowledge management and creativity management). This review considered the independent relationship of each of these factors to four innovation capacity measures. The people management practices did not show significant effects for individual practices, but the bundling of 'high performance' work practices (particularly around the organisation of work) demonstrated a positive relationship with higher levels of innovation capacity, particularly in product innovation. Support for organisational training and learning and knowledge and creative linkages to external organisations were also associated with different innovation capacity factors.

In summary, the results from the employer survey suggest that the original two-stage model which informed the research project is correct. None of the stimulus factors was linked to changes in innovation performance. The relationship between the stimulus factors for innovation and innovation performance is mediated by the enterprise's innovation capacity. There appear to be quite strong links between a number of the stimulus factors and innovation capacity. In particular, the stimulus factors that appear to develop higher levels of innovation capacity include:

- ✧ positive attitudes and support for organisational learning and training
- ✧ the use of flexible work practices
- ✧ the bundling of high performance work practices
- ✧ linkages with external organisations, particularly with educational institutions such as universities and TAFE.

It is these factors that comprise the most important drivers of developing enterprise innovation capacity and so have a positive influence on the final innovation performance of the enterprise.

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Capabilities, innovation and performance: an assessment using Australian data

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This chapter reviews the literature on organisational resources as precursors of firm performance. We note the importance in this literature of the deployment of routinised resources (bundled as skills). We explore, using data from the Australian Bureau of Statistics, the co-occurrence of skills, innovation and organisational performance. Our findings argue for the notion that firms assemble portfolios of skills that support the development of their higher-order innovation-related capabilities. As we anticipated, however, we find that these innovation-related capabilities and activities have a complex and nuanced relationship with organisational financial performance.

Capabilities, innovation and performance

Successful firms, which might be understood as firms that generate ‘rents’ or superior profits over time, tend to have resources and capabilities that their competitors do not have. These resources stay embedded within firms for many reasons. Intellectual property regimes like patents may protect certain key technologies. Firms may develop these resources internally, or may acquire property rights to these knowledge assets below their true value. In either case, the fact that firms are successful may be illustrative of their superior ability to understand the value of knowledge resources, their private knowledge of this information, or indeed through their good luck.

As an example of uncertainty in strategic factor markets, Makadok (2001) cites Microsoft’s 1980 purchase of the QDOS operating system, the forerunner to MS-DOS, for the sum of \$50 000. He notes the billions of dollars that Microsoft has generated in the subsequent three decades that have flowed from this purchase and its prescience (or its holding of private information) in relation to the importance of this knowledge in the nascent IBM PC standard.

In fact, as others have observed, this is only one part of the story of Microsoft’s later success. The QDOS code today is arcane. It has been Microsoft’s ability to reconfigure and redevelop this original, codified knowledge into a steadily growing range of applications that has been the foundation of its present success. Microsoft has been notably active and successful in protecting its formal rights to its codified knowledge, although it has been equally, and perhaps more, successful in developing a unique and defensible endowment of tacit knowledge resources that remains unrivalled.

The predominance of a tacit element within the skills repertoire of knowledge workers in Microsoft has acted as a notable ex-post barrier¹ to imitation and diffusion of know-how across geographical and organisational boundaries such that super-normal rents can be sustained over long periods of time. At least as much as their formal controls of the Windows operating systems and related applications through patents, it has been the firm's success in this build-up of tacit knowledge in rapidly developing new versions of its products and services that has been fundamental in defining its success.

Skills for innovation and competitiveness

Indeed, Microsoft's success in operating systems and other software could also be considered a classic example of what has come to be known as the 'dynamic capabilities perspective'. Such a perspective, outlined by Dierickx and Cool (1989), Teece, Pisano and Shuen (1997) and others, notes that it is the deliberative and deliberate processes of sustained capability building that create sustained competitive advantage.

In such an analysis, distinctive knowledge held within the tacit routines and resources of the firm serve both to sustain and define its competitive advantage. Firms bundle resources (tangible, intellectual and procedural) into ways of operating that their competitors cannot match. These resource bundles (which are competencies and skills) are complex, unique and, ideally, valuable for the sponsoring firm's customers.

In the strategic management literature, much work has been undertaken over the last three decades seeking to explain variations in the performance of competing firms, based on resource and capability heterogeneity. In what has come to be known as the 'resource-based view' of the firm (Barney 1991) there is an emphasis on resource-stock uniqueness (sustained through some absolute or relative barriers that prevent acquisition or replication by competitors).

A complementary and related literature (indeed, both draw on Edith Penrose's [1957] work) was initiated by Nelson and Winter (1982). Nelson and Winter define firm competitiveness according to the capacity to create and maintain effective routines and skills, which they define as 'a capability for a smooth sequence of coordinated behavior that is ordinarily effective relative to its objectives, given the context in which it occurs' (Nelson & Winter 1982, p.73).

In essence, skills and routines (as operationalised by Nelson and Winter) embody organisational resources (both tacit and tangible), which are intentionally and effectively deployed and systematically and dynamically improved. As such, they are the means by which firms create value, and (in theory) allow firms to derive rents (maintain competitive heterogeneity) over time.

We draw on these two related literatures for this chapter in two ways. Firstly, we seek to consider the link between capabilities and routines in certain key areas and their impact on the innovations introduced by firms. Our working hypothesis is that there are links between the skills and capabilities employed and the forms of innovation undertaken by firms. Firms' effectiveness relies on their configuring the right types of organisational routines and skills with concomitant forms of innovation to achieve success.

Secondly, we assess the impact of innovation on performance. Innovation cannot be considered an end in itself in terms of business performance. Many innovative firms fail if markets fail to appreciate their innovations or if the complex and interdependent sub-processes of innovation are not configured effectively. We also assess, for this paper, the performance impacts (variously measured) of different types of innovation.

¹ Ex-post barriers emerge after the introduction of a product or service. They inhibit the duplication of the innovation by a firm's competitors.

Empirical analysis employing Australia's Business Longitudinal Database

The Business Longitudinal Database (BLD) follows the earlier ABS development of the influential Business Longitudinal Survey, which ran from 1994 to 1999 and provided the basis for extensive analysis of Australian businesses. Following significant demand from a range of users, specific funding for the development of the BLD was included in the 2004–05 federal Budget. This funding also specified a requirement for the development of a longitudinal study of businesses in the food industry. These requirements were combined into a single new statistical initiative, the Business Longitudinal Database.

The BLD includes data from the Australian Taxation Office as basic annual financial information in relation to the businesses concerned, such as dollar values for total sales, export sales, other GST-free sales, capital purchases, non-capital purchases, and total salary, wages, and other payments. In the course of our analysis we utilised total sales, non-capital purchases, and total salary, wages, and other payments variables.

The sample design is based on the use of panels that provide consecutive and representative samples of the Australian business population at the point in time that each panel is introduced into the BLD. A new panel is added each year and remains in the BLD for five years. As the BLD has only recently been released, we use the first panel for this analysis.

This research could be considered exploratory, rather than confirmatory, as it develops a very generalised and stylised working model. (The presence of skills precedes the development of various forms of innovations, and these innovations lead to business performance.)

Defining/deriving: innovation

The BLD contains four aggregate measures related to innovation. These are derived from various survey items, which are then aggregated into new or significantly improved measures of:

- ✧ goods and services
- ✧ operational processes
- ✧ organisational/managerial processes
- ✧ marketing methods.

We used these four derived binary variables in our analyses, but also derived two additional items:

- ✧ any innovation (for example, identified businesses who responded affirmative to any of the above)
- ✧ ‘...’ innovation (this identifies businesses innovating goods and marketing concurrently).

The following tables illustrate the variance between industries in relation to the prevalence of the various forms of innovation measured in the survey. The figures presented here are simple weighted mean frequencies of innovating enterprises. The last column(s) comprises enterprises performing any form of innovation, as measured in the BLD.

Table 1 Innovation frequencies by Australian industries (%)

	New goods or services			New operational processes					
	2005	2006	2007	2005	2006	2007			
Manufacturing	19.3	18.7	21.0	13.1	23.6	25.1			
Construction	2.5	6.7	21.2	4.3	4.3	24.4			
Wholesale	20.1	27.7	28.2	13.2	23.3	10.0			
Retail	15.6	21.0	16.1	12.4	17.8	15.9			
Accommodation, cafes, and restaurants	11.8	9.5	10.8	12.9	13.3	7.9			
Transport and storage	6.7	9.1	7.2	13.6	15.1	13.9			
Communication services	12.2	19.3	18.9	4.4	27.7	22.4			
Property and business services	8.8	12.0	7.8	8.8	12.6	8.4			
Cultural and recreational services	15.8	13.9	12.5	14.8	8.4	6.3			
Personal and other services	17.0	23.3	22.8	5.5	14.2	13.8			
Australia (ex. mining & agriculture)	10.3	13.9	15.5	9.3	13.4	15.6			

	New organisational processes			New marketing methods			Any innovation		
	2005	2006	2007	2005	2006	2007	2005	2006	2007
Manufacturing	10.8	13.1	11.6	nc	11.1	12.6	20.1	24.2	21.9
Construction	11.6	8.4	9.7	nc	1.8	5.0	14.3	10.4	24.1
Wholesale	6.2	15.7	8.8	nc	19.5	10.0	19.1	30.1	21.9
Retail	7.8	15.4	15.1	nc	17.8	13.4	17.1	29.2	18.4
Accommodation, cafes, and restaurants	13.4	19.9	12.3	nc	10.7	7.0	17.0	21.4	13.7
Transport and storage	5.9	8.1	6.4	nc	1.6	2.2	12.8	14.2	14.1
Communication services	7.5	10.3	17.4	nc	6.2	7.5	10.7	24.2	18.7
Property and business services	10.7	13.6	11.6	nc	6.6	6.0	11.2	16.7	10.0
Cultural and recreational services	13.4	11.7	8.4	nc	15.0	13.6	22.5	19.2	16.7
Personal and other services	13.3	8.8	13.4	nc	14.6	17.6	23.1	25.8	25.0
Australia (ex. mining & agriculture)	10.1	12.7	11.2	nc	8.7	8.0	15.1	19.2	17.3

Note: nc = not collected.

While the year-to-year variances raise some questions about the survey's measurement validity,² some general impressions can be formed about the data. Firstly, there is significant variance between sectors in relation to the types of innovation being pursued and the overall pursuit of innovation of any type. Secondly, observed innovation seems to be highly context-specific. For example, the most prevalent forms of innovation in manufacturing are in the creation of new products or services and in the adoption of new operational processes, while the wholesale, retail and accommodation/cafe/restaurant sectors tend to innovate more strongly through the introduction of new organisational processes and marketing methods.

Skills, capabilities and innovation

As discussed earlier, we would expect, a priori, a positive and significant relationship between skills use and innovation. The following two tables provide some evidence for this association. Table 2

² There were significant changes in the Australian economy coinciding with the first three years of the BLD. These were primarily driven by rapid changes in the value of mineral exports, and the direct and indirect impacts that this had on the mining sector, related suppliers and firms in unrelated industries.

presents a cross-tabulated summary of the evidence from weighted data from the BLD survey. The skills used data were only available for 2007.

Table 2 Skills use by type of innovation for Australian industries (%) 2007

Skills used	Skills used as a percentage of those who innovated				
	New goods/ services	New op. processes	New org. processes	New market. methods	Any innovation
Engineering	13.4	12.7	11.1	9.7	9.0
Scientific & research	11.6	3.2	8.2	12.0	6.5
Information technology	36.0	41.8	46.4	39.3	33.5
Trades	30.9	22.6	18.6	18.3	21.9
Transport, plant, machinery operation	11.8	10.4	10.3	9.5	9.5
Marketing	32.6	32.3	47.2	61.7	39.2
Project management	9.8	10.9	10.7	12.2	6.8
Business management	22.9	42.0	48.6	20.3	31.6
Financial	25.3	39.5	50.7	25.6	28.8

The following table uses unweighted data, due to the fact that the way the ABS releases BLD data precludes some tests. It presents the probability of a significant relationship between skills use and innovation type using Chi-square tests of association. The table provides some strong evidence of the significant correlations between skills used and innovations occurring within firms. Significant associations ($p < 0.10$) (that is, the co-occurrence of skills used and innovation occurring could be considered as significantly associated) are shaded.

Table 3 Chi-sq (p-values) showing relationship between innovation type and skills use 2007

Skills used	Innovation type			
	New goods/ services	New op. processes	New org. processes	New market. methods
Engineering	0.08	0.01	0.07	0.47
Scientific & research	0.00	0.04	0.30	0.18
Information technology	0.57	0.00	0.00	0.06
Trades	0.09	0.14	0.69	0.83
Transport, plant, machinery operation	0.77	0.00	0.09	0.83
Marketing	0.04	0.25	0.01	0.00
Project management	0.15	0.08	0.01	0.36
Business management	0.02	0.03	0.00	0.83
Financial	0.73	0.00	0.00	0.60

Table 3 provides some evidence that the introduction of new goods and/or services entails the concurrent deployment of engineering, scientific, trades, marketing and business management skills and capabilities. In some senses, the introduction of new goods and services is the most evident form of innovation from a market-facing viewpoint, with other innovation types either more inwardly focused or perhaps more subtle in their impact. The introduction of new products and services, from a skills-use viewpoint, has a bias more towards the use of more fundamental activities; namely, engineering, research and trades-based activities.

The introduction of new operational processes differs in its co-occurrence with skills use, deploying engineering, scientific, IT, transport/plant and machinery operation, project management, business and financial skills. Further, this form of innovation uses a variety of skills more intensively—as

flagged by highly significant ($p < 0.05$) co-occurrence of this innovation form with the deployment of engineering, scientific, IT, transport/plant/machinery, business management and financial skills.

Similarly the introduction of new organisational processes can be viewed also as a systemic form of innovation, vis-a-vis its widespread use of a variety of skills. The two forms of skills that are not concurrently deployed with this form of innovation are scientific and research and trades-based skills.

Marketing-based innovations seem to be the most superficial in relation to their use of the firms' skills and capabilities. This form of innovation employs (as you would expect) marketing-based skills and also IT skills, but it does not seem to co-occur with the use of more fundamental operational skills sets within organisations.

Defining/deriving: business performance

One of the key objectives of this analysis was an investigation of the relationship between innovation and business performance. While there are various ways to assess business performance, for example, in relation to the BLD, the ABS suggests as possible indicators, business survival, growth/decline in overall size of business, performance ratios from financial measures, and changes in business productivity. In this analysis we generally make use of the latter two derived financial measures.

While there are some items relating to the subjective assessment of business performance on the BLD (for instance, questionnaire items on self-assessed performance in relation to competitors or performance change over time), there are no outright objective measures of business performance, such as productivity. Therefore it was necessary to define objective measures of business performance, which, in the framework of the available data in the BLD, was limited to a derived variable employing Customs or/and ATO data. The variables available for such derivation were thus total sales, export sales, other GST-free sales, capital purchases, non-capital purchases, and total salary, wages and other payments.

We thus derived the following measures as possible indicators of business performance:

Value added: $Valadd_t = sales - purchases$

Normalised value added: $Valaddnorm_t = \frac{sales - purchases}{purchases}$

Labour productivity: $Labprod_t = \frac{sales - purchases}{salaries}$

Sales growth: $salesgrowth_t = \frac{sales_t - sales_{t-1}}{sales_{t-1}}$

Labour productivity growth: $labprodgrowth_t = \frac{labprod_t - labprod_{t-1}}{labprod_{t-1}}$

There are two subjective measures of business performance in the BLD dataset. We compared these with the above derived measures in an effort to evaluate an assumed relationship between the two types of performance measures. The resulting estimates (table 4) represent the weighted correlations between subjective and objective performance indicators. (This was done with 2005 data, as the subjective variables are not available for other years on the BLD.)

As with the other analysis results, data have been cleaned and outliers winsorised³ prior to correlation calculation. Potentially influential outliers, especially in terms of financial indicators

³ Data winsorisation is a statistical technique that is used to reduce the impact of outliers within a sample.

derived where there is strong variance in denominator revenue and cost figures, have been excluded where appropriate.

Table 4 Correlation of subjective and objective measures of performance across industries, 2005

		Labour	Normalised	Labour prod.	Sales
		Productivity	Value-added	Growth	Growth
How do you assess your profitability compared with your competitors	Correlation	0.1071	0.17372	-0.00706	0.05393
	Significance	0.0025	<.0001	0.8425	0.1282
How do you assess your productivity compared with your competitors	Correlation	0.14032	0.27023	-0.01729	0.04642
	Significance	<.0001	<.0001	0.6155	0.1766

As is shown in table 4, subjective and objective assessment of labour productivity and normalised value-added correlate significantly, albeit only mildly (correlation between self-assessed productivity and our derived labour productivity is 0.14 (sig. at <.001) and derived normalised value-added is 0.27 (sig. <.001).

There is no evident correlation between subjective assessment and either labour productivity growth or sales growth. (It should be added that the growth variables lag the subjective variables by one year.) This may indicate that our performance measures are, while quite useful, far from ideal or, alternatively, self-assessment may be inaccurate, or a mixture of both.

Innovation and firm performance

As has been noted, prior research generally presents a highly ambiguous relationship between innovation and performance. Nevertheless, firms and managers are assumed to be acting rationally when pursuing innovation, and hence the models in this paper are presented with an implied positive relationship between business performance and innovation, with either no or a minor lag between innovation and the performance measure.

Table 5 Australian industries' performance—various measures

	Labour productivity growth		Sales growth	
	2005–06	2006–07	2005–06	2006–07
Manufacturing	-0.1	-0.3	0.5	0
Construction	0.1	-0.3	0.5	-0.1
Wholesale	-3.3	-0.4	0.4	0
Retail	-0.1	-0.2	0.1	-0.1
Accommodation, cafes, and restaurants	0.8	0.7	0.2	-0.1
Transport and storage	-0.4	0.3	0.2	0
Communication services	-0.1	-0.2	0.4	0.2
Property and business services	0.1	0	0.1	0
Cultural and recreational services	0.7	-0.5	0.3	0
Personal and other services	-0.1	0	0.1	0
Australia (ex. mining & agriculture)	-0.2	-0.1	0.3	0

Table 5 displays weighted means for labour productivity growth and sales growth, as derived by the aforementioned methods. Significant outliers were winsorised to the 1st/99th percentile. As with all other tables, the (small) mining and agricultural enterprises were left out of the analysis, as were micro enterprises (<6 employees).

Generally, evidence suggests a degree of stability in terms of sectoral labour productivity and sales growth. These figures are consistent with a relatively stable and healthy national economy, leading up to the emergence of economic problems in late 2008 related to the Global Financial Crisis.

Table 6 Labour productivity by innovation type by year

Innovated in		2005			2006			2007		
		05	06	07	05	06	07	05	06	07
New/improved goods or services	Innovators	2.3	2.4	2.4	2.0	2.2	2.1	2.0	2.1	2.2
	Non-innovators	2	1.7	1.8	2.3	1.9	2.1	2.3	1.9	2
New/improved operational processes	Innovators	2.3	2	2.1	2.5	2.4	2	2.0	1.5	1.6
	Non-innovators	1.9	2.1	2.1	1.7	1.6	2.2	2.3	2.6	2.6
New/improved organisational processes	Innovators	1.8	1.8	1.7	2.0	1.9	2.0	1.7	1.6	1.8
	Non-innovators	2.5	2.2	2.5	2.2	2.2	2.2	2.5	2.5	2.4
New/improved marketing methods	Innovators	nc	nc	nc	2.0	1.8	1.8	2.0	2.0	2.1
	Non-innovators	nc	nc	nc	2.3	2.3	2.4	2.3	2.1	2.1

Note: nc = not collected.

Table 6 shows the anticipated, yet paradoxical, relationship between innovation and organisational performance. Shaded cells indicate a significant variance between the two groups (innovators and non-innovators). While it is possible to observe directional variance between the introduction of innovation and firm performance (measured here according to our previously defined labour productivity measure), the lack of consistency of effects would suggest great care should be taken prior to extrapolating any robust conclusions from this analysis.

For instance, firms that do not introduce new and improved organisational processes seem to derive higher labour productivity than firms that do introduce these innovations. There is some evidence that firms that innovated in terms of goods or services in 2005 derived higher labour productivity in 2006, but this effect is not replicated for similar innovators in 2006 and 2007. This would suggest that great care should be taken prior to extrapolating any robust conclusions regarding the relationship between innovation and business performance from the above comparisons.

A number of caveats relating to the interpretation of the above table are important. Foremost among these are issues of measurement. We would expect labour productivity to be influenced by many factors (confounding variables) that we have not been able to include in our analysis. The second caveat relates to timing issues. Innovation often requires investments (in research, staffing and facilities) in anticipation of future revenues. As such, often innovation may precede revenue growth by many months or years, and hence low productivity may occur as costs are incurred without compensating revenues being concurrently achieved.

Table 7 Normalised value-added by innovation type by year

Innovated in		2005			2006			2007		
		05	06	07	05	06	07	05	06	07
New/improved goods or services	Innovators	1.2	1.1	0.9	0.7	0.6	0.5	0.6	0.7	0.6
	Non-innovators	0.8	0.6	0.7	1.3	1.1	1.1	1.5	1.1	1.0
New/improved operational processes	Innovators	1.1	0.8	1.0	1.2	1.0	0.9	1.4	1.3	1.2
	Non-innovators	0.9	0.9	0.7	0.8	0.7	0.7	0.6	0.4	0.4
New/improved organisational processes	Innovators	0.8	0.6	0.5	0.4	0.4	0.4	1.3	0.9	0.9
	Non-innovators	1.2	1.1	1.1	1.6	1.3	1.2	0.7	0.8	0.8
New/improved marketing methods	Innovators	nc	nc	nc	0.9	0.6	0.5	0.6	0.5	0.5
	Non-innovators	nc	nc	nc	1.1	1.1	1.1	1.4	1.2	1.2

Note: nc = not collected.

Table 7 shows a more ‘standard’ measure of financial performance; namely, normalised value-added. Once again, while significant effects are evident in the table, there is no consistency in these effects as one might anticipate.

As such, these indicators point to either a highly ambiguous relationship between innovation and firm performance, or a highly contingent set of effects that are beyond the scope of this model.

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Appendix

Scope of the BLD

The scope of the BLD is basically restricted to businesses with a simple structure, with fewer than 200 employees, which report in excess of \$50 000 in sales of goods, and are not part of the following classifications:

- ✧ ANZSIC93 Division D Electricity, gas and water supply
- ✧ ANZSIC93 Division K Finance and insurance
- ✧ ANZSIC93 Division M Government administration and defence
- ✧ ANZSIC93 Division N Education
- ✧ ANZSIC93 Division O Health and community services
- ✧ ANZSIC93 Sub-division 96 Other services
- ✧ ANZSIC93 Sub-division 97 Private households employing staff
- ✧ ANZSIC93 Group 921 Libraries
- ✧ ANZSIC93 Group 922 Museums
- ✧ ANZSIC93 Group 923 Parks and gardens

Sample

The sample design involves the use of panels that represent the Australian business population at the point in time that each panel is initiated into the BLD. In our study, we restrict use to Panel One, which is representative of the in-scope business population as at 30 June 2005. This panel is directly surveyed once a year for a period of five years. Our study thus comprises data covering the years 2005, 2006, and 2007.

The sample is stratified by industry division and business size. Industry is based on ANZSIC (Australian and New Zealand Standard Industrial Classification) 1993 division, and business size is based on a derived employment size indicator. State/territory is not included in stratification.

Sample size was determined by the ABS after consultation with BLD users. It was found that a desirable sample size per stratum should be at least 30 businesses, which, taking attrition into account, meant a starting sample size of around 40 businesses per stratum. Therefore, the theoretical sample size for the entire BLD is approximately 2000 businesses per panel. The sample for the panel used in this analysis was selected from a survey frame created in June 2005 and included 2732 businesses. The population frame for this panel contained 1 563 857 businesses.

For this present paper, our preliminary analysis revealed that mining businesses displayed a pattern in our major business performance-related output variables that deviated from the pattern of the majority of businesses on the BLD. This may be related to the capital-intensive structure of such enterprises (for example, most small mining businesses tend to be explorers with no positive cash flows). Agricultural businesses were excluded for similar reasons. Our analysis thus excludes these two industries by themselves, as well as in aggregate national data.

Weighting

The BLD includes weights as design weights and longitudinal weights. Longitudinal weights are design weights adjusted for businesses which have failed to respond in all periods. Weights are based on the stratum (that is, industry division by business employment size) with the exception of units in agriculture, forestry and fishing; manufacturing; and wholesale trade. The ABS specifically

advises that use of the BLD to calculate population or cross-sectional estimates is not recommended, as the BLD sample is not allocated to enable the creation of such estimates with reasonable accuracy.

Data sources

Beyond the data obtained from survey responses, the BLD includes administrative data sourced from two government agencies outside the ABS. These include trade data sourced from Customs administrative data and data from the Australian Taxation Office. Our analysis included the use of administrative data from the ATO. Those variables comprised total sales, export sales, other GST-free sales, capital purchases, non-capital purchases, and total salary, wages and other payments. The reference period for these data corresponds approximately with survey data for the same period.

Missing data

Missing data may be incurred by questions not completed, questions not required to be completed, and questions not asked. Data missing due to questions not completed have not been imputed by the ABS. The ABS advises that internal research indicated that non-response in the majority of cases equates to a negative response.

Data may also be missing due to sequencing, for example, where a negative response results in the respondent sequenced past a number of questions regarding the same topic. Finally, there might be non-response due to questions not asked. This is mostly due to an effort to reduce respondent burden, for example, specifically in the 2006–07 period, where the use of different form types has resulted in some businesses not being asked the more detailed innovation questions.

Tradespeople and technicians in innovation

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This chapter provides an introduction to the concept of innovation and demonstrates the central role of the vocationally trained workforce, especially tradespeople and technicians, in the generation and diffusion of innovation in and across firms. This essay uses ABS survey data to establish that the primary form of innovation in Australia is incremental and that tradespeople and technicians are identified by firms as critical to their innovation efforts. It also presents the results of a large-scale survey of the role and contribution of VET-trained workers in Australian R&D laboratories. Despite the fact that tradespeople and technicians comprise around 45% of the business R&D workforce, both in Australia and overseas, this is the first study of its type to be undertaken globally. It demonstrates how this role is largely determined by their formal VET training and, for many, extensive work experience in production prior to entering the R&D workforce. It also identifies a number of constraints to their contribution and suggests changes which could improve the effectiveness of their participation and, arguably, the efficiency of the R&D process.

Introduction

The importance of the vocationally trained workforce, especially trades and technicians, in ‘incremental innovation’ is increasingly recognised in science and technology policy (OECD 2009, p.42). However, with a few notable exceptions (Prais 1995), the exact nature of this contribution to innovation has not been closely examined but is, instead, attributed loosely to manual skills and practical intelligence. The purpose of this chapter is to provide a brief introduction to the concept of innovation and summarise the key arguments in the literature on the significance of trades and technicians, and the VET-trained workforce more broadly, in innovation. It also presents, in summary form, the results of a recent study which examined in detail the contribution of trades and technicians to an important form of innovation, that is, R&D. The main findings are that, first, VET occupations play a critical and distinct role in R&D. This reflects the particular skills and knowledge gained through formal training and often the extensive experience gained prior to entry to R&D work. Second, work organisation within the R&D lab is a major factor in determining how effectively and efficiently these contributions are made. Finally, a move by the VET system during recent decades to give priority to practical competencies over theoretical understanding was argued by some VET R&D workers and university-trained researchers to be a retrograde step.

Innovation: what is it and why is it important?

The conceptual framework for analysing and undertaking empirical work on innovation in the OECD, the *Oslo manual* (2005), defines innovation as the implementation of improvements by firms to their products/services and production processes that are intended to confer a competitive advantage in the marketplace. Given the momentous role of organisational improvements in economic development, these too are captured in the official definition of innovation. (Think of the dramatic effect of new organisational forms, ranging from the Roman legion; displacement of the ‘putting out’ system of production by ‘manufactories’; the development of limited liability share ownership; the rise of the modern multi-division transnational corporation; to the ‘Toyota’ production system.)

The manual provides a detailed guide to the measurement of inputs to the principal forms of innovation—product, process and organisational—in terms of expenditure by private firms and the public sector on specific activities (table 1).

Table 1 Types of Innovation and typical associated expenditures

Product	Process	Organisational
Product design	Automating production	Quality systems
Capital investment for new/improved products	New software for supply-chain management	Improved business performance measures
Tooling-up and industrial engineering	New software for designing products	Data gathering to better meet customer needs
Acquisition of technology licences and trademarks	Outsourcing functions to call centres	Work organisation systems to encourage and capture ideas for improvements from its workforce
Training to introduce an innovation	Training of staff to offer new services to customers	
Marketing of new products		
R&D		

Technical and organisational innovation are crucial for a number of reasons, being the principal sources of productivity improvement, and productivity gains are the principal source of increases in real income per person. (Other sources of productivity growth are realised when: the returns from increased investment in capital per worker and/or ‘human capital’ through additional years of education exceed the cost of investment; structural change occurs from a reallocation of resources to more productive uses; and from increasing returns to scale, broadly conceived). Innovation is also the source of new products and services to satisfy a growing diversity of human needs and wants. Finally, the effect of innovation is cumulative, in that a certain level of innovation and R&D within a nation or a firm is necessary to be able to identify, evaluate and adapt technologies from outside the country or the firm; that is to say, the more innovation occurring within an economy, the greater the ‘absorptive capacity’ or ability to assimilate new technologies (Dahlman & Nelson 1995).¹

Innovation has profound effects on firms’ productivity and financial performance. In 2007–08, 38% of innovating businesses in Australia reported increased productivity over the previous year compared with just 18.7% of non-innovating firms; 38% of innovating firms reported increased profitability compared with just 26% of non-innovating firms (ABS 2009).² Basri (2006) found that on average Australian innovating firms attributed 13% of their turnover in 2002–03 to new

¹ Despite demonstrating the critical role of technical change in productivity growth, orthodox economics has little to say about its sources and implementation. This is because it regards capital and labour as homogenous factors of production and must treat technical change as exogenous to the system, otherwise it gives rise to oligopoly or monopoly (Kaldor 1972; Freeman 1998). The development of ‘new growth theory’ over the 1990s was an attempt to reconcile reality with theory within an equilibrium framework (Thirlwall 2002, Ch. 2).

² Crucially, these results are independent of employment size and industry of innovating firms.

products or services introduced over the period 2001–03.³ Innovating firms spent 2.4% of total business expenses (roughly approximating turnover) on innovation in 2002–03. Of this, just under half was for the purpose of introducing a new good or service. This implies that the effect of innovation on firms' turnover significantly exceeds the cost of introducing a new good or service (even assuming the new goods or services were under development over the three-year period).

Radical and incremental innovation

The innovation studies discipline has identified two broad types of innovation: radical and incremental. This distinction, as Christopher Freeman (1998, p.30) argues, 'is an important one because the two types of innovation embody a very different mix of knowledge inputs and have very different consequences for the economy and the firms which make them'. Radical innovations give rise to major technological, economic and social change and, over the last 100 years, are typically the outcome of massive public and/or private investment in fundamental science and applied R&D. These innovations are 'disruptive'; in Schumpeter's (1943) famous phrase they generate 'gales of creative destruction' by making existing products, production systems and skills technologically redundant. The radical form requires elite scientific, engineering and design occupations, or in the case of breakthrough organisational systems, high-level and original management skills and large, long-term investments by firms.

By contrast, incremental innovations 'involve endless minor modifications and improvements in existing products, each of which is of small significance but which, cumulatively, are of major significance' (Rosenberg 1994, pp.14–15). The innovation studies literature has shown that incremental innovation is the principal source of productivity growth within firms and the economy as new applications are found for existing technologies and as these technologies undergo gradual optimisation and the scope of their application is extended. Crucially, for the argument in this chapter, the literature has also shown that optimising and extending technologies is commonly performed by the broader workforce. The 'cumulative productivity impact of small incremental changes that are usually undertaken on the shop floor can be much greater than initial introduction of a major technology' (Dahlman & Nelson 1995, p.95).

However, the extent to which tradespeople, technicians and other occupations within a firm actually contribute to incremental innovation is mediated by the presence of work organisation arrangements which encourage and reward active participation in improving process, products and services (Tidd & Bessant 2009). There is now an enormous empirical literature on innovation and work organisation. The principal claim of these studies is that advancing:

new products and services ... depends critically on the skills developed by employees on the job in the process of solving ... technical and production-related problems ... Developing these sorts of skills in turn depends not just on the quality of formal education, but also on having the right organisational structures and work environments. Work environments need to be designed to promote learning through problem solving and to encourage the effective use of these skills for innovation. (Arundel et al. 2006, p.1)

(This chapter provides concrete examples of the important effect of these work organisation arrangements in an R&D setting).

The principal causes of incremental innovation are 'learning by doing' and 'learning by using'. In almost all fields of production of goods and services, the repetition of production tasks leads to a

³ This is not to imply that the entire turnover attributed to a new product or service represents net growth in turnover; for some firms the revenue from a new product or service simply displaces an older product or service. These data also do not imply that all innovation expenditures result in improvements, since a proportion of all 'experiments' with altered products, services and processes fail or are dumped. In 2006–07, 36.8% of all firms undertook some form of innovation, but 5.8% of all firms 'abandoned' their innovations (ABS 2008, table 1). The 36.8% includes firms that abandoned innovations.

gradual improvement in the efficiency of production processes through the evolution of product designs, production systems and training. Indeed, these efficiency gains through ‘learning by doing’ are so regular that there are mathematical formulas demonstrating large cost reductions per cumulative increase in total output for many different commodities (Arrow 1962). The importance of such ‘learning by doing’ processes has long been recognised, as has the central place of direct production workers in innovation as sources of work-based learning (Landes 1972). Learning by using, also known as user–producer interaction, entails the flow of information from users of products or services to their producers (Rosenberg 1982, pp.121–2; von Hippel 1988, 2005). Users of capital, intermediate or consumer goods or services can provide regular feedback to the producers of these goods and services, communicating suggestions for design and other changes which extend their range of uses, improve their performance or reduce their cost. Learning by doing and using are the result of the accumulation of knowledge generated by learning in the production process or in the consumption of goods and services.

The role of technician and trades in innovation

The purpose of this section is to provide a brief account of some of the evidence for the role of technician and trades in innovation. This evidence is based on the official definition of the activities of these occupations, data from surveys of innovation in Australia, and other studies of the effect of international differences in the quality of the trades and technicians workforce on firm and national economic performance.

Defining trades and technicians

The Australian and New Zealand Standard Classification of Occupations (ANZSCO) (ABS 2006a) provides a description of the broad range of activities in which technicians and tradespeople are engaged and the skills and knowledge required to perform these activities. Entry to technician occupations typically requires an associate degree, advanced diploma or diploma, or at least three years of experience. Examples of these occupations include medical, science and laboratory technicians; engineering, electrical and architectural draughtspersons; and hardware and software support technicians. Entry to tradespersons occupations typically requires an Australian Qualifications Framework (AQF) certificate III–IV, including at least two years of on-the-job training, or at least three years of relevant experience. The principal distinction in terms of skill level between trade and technician occupations is that the latter is involved in more complex problem-solving, such as non-routine plant installation and fault-finding and requires higher-level formal training in the design of equipment, systems, structures and supervision of staff.

‘Technicians and Trades workers perform a variety of skilled tasks, applying broad or in-depth technical, and trade or industry specific knowledge, often in support of scientific, engineering, building and manufacturing activities’ (ABS 2006a). A key role of these occupations is to *design, install, commission, adapt, operate and maintain* equipment, software and other technologies.⁴ These activities are precisely those that are at the centre of much learning by doing and using.

Australian innovation surveys

The claims in the innovation studies literature that ‘incrementalism’ is the predominant form of innovation and that the vocationally trained workforce, especially tradespeople and technicians, plays an important role in this form are consistent with data from official surveys of innovation in Australian business. First, that most innovation activity is incremental is confirmed by businesses

⁴ This list of verbs to describe the activities of tradespeople and technicians can also be found in many relevant training packages such as those for metal, electrical and communication occupations.

who report overwhelmingly that their innovation activity involves copying or adapting improvements from similar firms or from other industries (table 2).

Table 2 Proportion of firms reporting novelty of innovation, 2004 and 2005, Australia (%)

Type of innovation	New to business	New to industry	New to country	New to world
Product/service	74	20	15	>1
Process	87	11	4	1
Organisational	94	6	1	>1

Note: The rows do not sum to 100% as firms could provide multiple responses to each question if they were unable to allocate the degree of novelty of an innovation to a single category.

Source: ABS (2006b, table 2.13).

The importance of learning by doing and using is also underscored by the fact that the most frequently cited sources identified by businesses as the origin of the ideas for their innovations arise from learning inside the firm and from learning amongst customers and suppliers (table 3). Firms are also heavily reliant on learning from competitors and publicly available information. Firms are much less reliant on information from organisations whose role is to generate new knowledge (universities) or on paying organisations to generate new knowledge on their behalf (R&D labs). This is not to diminish the importance of these latter sources; it is simply to note that most innovation entails learning from within the firm or within the firms' supply chain.

Table 3 Proportion of firms nominating sources of ideas or information for innovation, 2006–07, Australia (%)

Inside firm	Clients, customers	Suppliers	Competitors	Websites, journals	Higher education	Commercial laboratories
55.5	44.1	31.7	31.7	31.8	2.6	2.0

Note: Firms could identify more than one source.

Source: ABS (2008a).

Innovation surveys also collect data on 'skills used for innovation activities'. However, for the occupations that are the focus of this chapter, the data are limited. This is because 'trades' only are separately identified, with technicians included under a number of other skills such as 'engineering' and 'scientific and research'. Despite these limitations, which have the effect of underestimating the significance of these combined occupations in innovation, trades emerge as being notably important (table 4).

Table 4 Proportion of firms nominating selected skills used for innovation activities, 2006–07, Australia (%)

	Engineering	Scientific & research	IT	Trades	Marketing	Business management	Finance
Manufac.	30	12.3	24.9	33.3	27.8	27.6	17.7
Construc.	10.7	7.7	26.6	43.4	32.4	22.7	28.2
Other services	5.3	1.7	24.4	41.4	27.2	24.2	12.8
Total*	9.9	8.0	35.4	19.3	33.7	31.1	21.2

Note: Firms could identify more than one source. The total is for all industries not just the three listed.

Source: ABS (2008a).

Across all industries trades are the fifth most commonly cited skills used for innovation.⁵ For industries in which trades are a significant share of the workforce, that is, manufacturing, construction and other services (in the latter, repair and maintenance of machinery and equipment is a large element), trades are the most frequently cited source of skills used for innovation. The survey also asked innovating firms to identify which skills needed for undertaking innovation were in shortage. Trades are the most frequently cited type of labour shortage (table 5).

Table 5 Shortages or deficiencies in skills needed to undertake innovation 2006–07, Australia (%)

	Engineering	Scientific & research	IT	Trades	Marketing	Business management	Finance
Manufac.	10.5	2.0	3.9	20.0	6.1	6.4	6.7
Construc.	8.9	2.8	8.1	32.9	2.6	8.4	3.6
Other services	1.1		5.4	24.3	0.3	2.2	5.4
Total*	4.6	2.0	7.3	14.1	4.6	5.6	5.1

Note: Firms could identify more than one source. The total is for all industries not just the three listed.

Source: ABS (2008a).

Other studies on trades and technicians in innovation

Another field of study examines the effect on economic performance, in terms of productivity, quality and capacity for innovation, arising from differences across nations in the skills and qualifications of the direct production workforce. This section briefly describes studies that have used ‘matched plant’ comparisons and differences in the structure of foreign trade to explain the role of workforce skills in innovation.

Matched plant studies

These studies compare firms’ performance in the United Kingdom and Europe (Germany, France and Holland) across a broad range of manufacturing, construction and service industries (Prais 1995; Mason, Van Ark & Wagner 1996; Anderton & Schultz 1999; Clarke & Wall 2000; King 2001; Clarke & Hermann 2004). They attempt to ‘match’ plants producing similar commodities across countries and control, where possible, for factors such as the differences in capital equipment, product type and regulations that occur across nations. The goal is thereby to eliminate explanatory variables apart from differences in workforce skills.⁶ Historically, the UK has had a much higher proportion of the direct production workforce with no qualifications, and those with qualifications are on average at a lower level than in the European workforce.⁷ Wide differences in the conception of skill and in the content and delivery of vocational education give rise to a large variation in the performance of vocationally trained workers across countries. It has been argued that in the UK vocationally trained workers are less able to deal with technological change and

⁵ The ABS innovation survey identifies two other skills in addition to those listed in tables 4 and 5. These are ‘project management’ and ‘transport, plant and machinery operation’. These two are cited less frequently than those listed in the tables above. Of the total nine skills identified, trades are the fifth most frequently cited skills used for innovation and the most commonly cited skills in shortage.

⁶ In practice the studies reveal that it is not possible to control for these variables as the wide divergence across advanced nations in product quality and production methods is linked in a self-reinforcing manner to large differences in workforce skills.

⁷ Over the last decade this has changed as UK Government policy has encouraged the acquisition of formal vocational qualifications by the workforce. Despite conferring some benefits, such as higher rates of employment for holders of these qualifications, the effect of these qualifications on worker productivity, as measured by wage increments to qualification holders, is minimal. This is attributed to factors such as low level of prior educational attainment and limited content of the UK vocational qualifications (Wolf, Jenkins & Vignoles 2006; Vignoles & de Coulon 2008; Brockmann, Clarke & Winch 2008).

more complex problem-solving: 'as people are required to perform to narrowly prescribed competencies, they do not have the knowledge, skills or indeed, the motivation to perform tasks or deal with situations beyond the prescribed outcomes' (Brockmann, Clarke & Winch 2008, p.553). The matched plant studies revealed large productivity differences between UK and European firms, for example, in manufacturing of up to 100%, and 37% in construction (Prais 1995; Clarke & Hermann 2004).

A number of factors have been identified which translate national differences in the quality and quantity of VET-trained workforces into national differences in productivity, quality and innovation. These include:

Lower defect rates

A significantly higher defect and re-work rate in British plants leads to lower physical output and hence lower productivity. In European plants the employment of more skilled and trained production and maintenance persons allowed for more automated control of production processes and closer tolerances of work.

Lower ratio of direct to indirect labour

Production in the UK is characterised by a higher ratio of indirect labour, such as foremen, supervisors and clerical support. This was a function of the higher defect rate and the use of quality control systems in the UK, which necessitates more quality checkers.

Higher capacity-utilisation rates

A higher rate of plant breakdown in the UK sample was attributed to inadequate plant maintenance in the British plants and, more specifically, to inadequate preventative maintenance programs. In turn this is the result of 'differences in the skill levels of maintenance teams—although inadequate technical skills at intermediate management level must bear a share of the blame' (Prais 1995, p.71).

Improved scope for product and process innovation

Firms with a higher proportion of more skilled direct production workers, in general, adopted 'flexible specialisation' production methods, which allowed for both the customisation of products and the more rapid introduction of new products.

At its most fundamental, the supply of VET skills is influential in determining not only what goods and services are produced in a national economy, but how they are produced. 'Firms' product market choices are constrained by the availability of necessary skills' (Estevez-Abe, Iversen & Soskice 2001, pp.38–9).

National differences in the structure of exports and imports

A related approach to examining the links between innovation and vocational skills has been to examine cross-country differences in trade performance and the differences in the composition of workforce skills (Oulton 1996). It has been found that countries with an above-average proportion of skilled vocational workers in their workforces have above-average trade performance in products that intensively use these skills. Countries such as Germany and Japan which 'provide broad-ranging, company-based training for particularly high proportions of their workforce' demonstrate especially strong performance in intermediate skills products such as motor vehicles, machine tools, and power-generating equipment (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 UK and the US have world-class research universities, especially in basic sciences, engineering, management and the creative industries such as design and media. These universities also have strong links with

industry. Both countries have an above-average performance in high-skill-intensive exports such as software, aerospace, advanced defence equipment, biotechnology, financial services and media. 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). It is interesting to note that the export volume of these high-skill products from the US and the UK 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).

It is important to note that higher-level vocational skills, while important, are but one factor in the innovation system of nations such as Germany and Japan. Many other elements have been identified in these systems, such as technology diffusion programs, government procurement policies and capital markets that give priority to long-term investing rather than short-term speculation and asset trading (Streeck & Yamamura 2001).

A case study of VET and innovation

To date, research on the role of the vocationally trained workforce in incremental innovation has focused exclusively on the production of goods and services intended for immediate sale. It has not examined the role of these occupations in other innovation activities, notably R&D. This deficiency is important, as R&D is a critical part of, and contributor to, innovation (table 1) and in 2006–07 these occupations comprised 46% of the Australian business R&D workforce and 31% of the total Australian R&D workforce (ABS 2008b). In the European Union 45% of persons engaged in business R&D in 2005 were classified as 'technicians and other supporting' (OECD 2006, tables 27, 30). To address the gap in Australia, the Department of Education, Employment and Workplace Relations commissioned research into the role and contribution of trades and technicians in R&D in Australia (Toner et al. forthcoming). This section draws selectively on these data to illuminate the major themes in the literature on VET and innovation presented in the previous section. Firstly, it provides more empirical detail on the activities tradespeople and technicians undertake and their specific contributions to innovation (at least within an R&D setting). Secondly, it examines the role of VET qualifications and prior work experience to this contribution. Finally, it identifies how work organisation arrangements within R&D mediate the contribution of these occupations to R&D.

Methodology

Primary data for the study were collected via a semi-structured interview instrument conducted through 103 face-to-face interviews. They included 71 tradespeople and technicians, with the remainder mostly comprising R&D managers and a small number of human resources managers. Interviews were conducted at a total of 16 separate enterprises, comprising five public sector, nine private firms and two 'hybrids'. The latter were cooperative research centres (CRCs), which are dependent on both public and private funding. The public sector consisted of four research agencies and a public university. An attempt was made to ensure that the sample of enterprises interviewed were broadly representative of key characteristics of R&D activity in Australia, such as in: the distribution of employment between public and private sectors; the employment size of enterprises; their geographical distribution; and the diversity of technologies.

The Australian R&D workforce

The classification system used in the collection of R&D statistics across developed nations, the *Frascati manual* (OECD 2002), distinguishes three broad groups within R&D: researchers, technicians and other supporting. The manual defines these groups in terms of both occupation (based on the International Standard Classification of Occupations) and qualification (International Standard Classification of Qualifications). Researchers are university-qualified professional

occupations such as scientists, engineers and research managers. Technicians comprise persons classified to the International Standard Classification of Occupations Major Group 3 ‘technicians and associate professionals’, notably in physical and engineering science; biology and health; computing; and statistical occupations. The typical entry requirement is a diploma or advanced diploma. ‘Other supporting staff includes skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects’ (OECD 2002, p.94). The ABS largely follows the advice given in the manual and uses an occupation or task-based approach to classify persons into one of the three broad groups (OECD 2002, p.93). Such an approach has the advantage of lowering respondent burden since data on qualifications are not collected but, as will be shown below, this does give rise to a number of problems.

There is considerable variation in the share of these occupations across the different sectors undertaking R&D. For example, technicians and other supporting comprise just 13% of the higher education R&D workforce, but 46% of business and 48% of government R&D workforces respectively (ABS 2008b). The study found there is also considerable variation across different R&D workplaces in the scope of activities undertaken by trades and technicians and in the level and source of their qualifications. The most obvious source of variation is that the term ‘technician’ or its equivalent is applied to people with qualifications ranging from certificate III to PhD. There is also no clear distinction between trades and technicians in terms of current job titles, as the job title of some people with a certificate III–IV was technician or a related job classification. The main division within VET-trained technicians was between those whose first qualification was a certificate III–IV trade, or those whose first qualification was at diploma or equivalent level in a trade-related field, such as electrical or mechanical engineering or draughting. The latter tended to be engaged more in design, project management or other related duties and were less likely to be found in more ‘hands on’ roles in workshops. Many of those whose first qualification was trade certificate III–IV proceeded to diploma or equivalent level studies but were more likely to be engaged in ‘hands on’ work.

There was an equally pronounced variation in the definition of researcher. One private sector principal scientist interviewed only had the equivalent of an advanced diploma as his highest qualification. These variations reflect the differences in technology (advanced versus standardised) and the purposes of the R&D (pursuit of knowledge versus modifying a product for the market) across the sites.

In summary, the study found there is difficulty aligning the occupational titles and qualifications of personnel engaged in R&D. This great diversity in the level of education of ‘technicians’ represents a potentially important impediment to workforce and educational planning for the R&D sector. At present there is no comprehensive, authoritative description of the Australian R&D workforce in terms of the usual parameters used by educational and workforce planners such as age and a cross-classification of occupation and qualification. Apart from the ABS survey of public and private establishments conducting R&D, with its current limitations, there is no alternative data source on the R&D workforce.⁸

What do trades and technicians in R&D do?

Five major roles for trades and technicians in R&D were identified. Most of these roles were performed by these occupations but the time spent on these roles varied widely across the two broad occupational groups and across the sites interviewed. The exceptions would be ‘linking of R&D to production’ and ‘teaching’, the former occurring only in private sector R&D, where research is directly linked to commodity production; the latter was observed only in higher education.

⁸ The report made a number of recommendations to address these deficiencies.

Use of tools, instruments and machines

A central role of all tradespeople and technicians related to the use of tools, instruments and machines. These occupations were responsible in part or whole for:

- ✧ identifying and sourcing equipment
- ✧ installing and commissioning equipment
- ✧ operating, maintaining, fault-finding and calibration of tools and equipment
- ✧ adapting equipment and instruments to perform novel functions or achieve particular performance characteristics required by a researcher
- ✧ integrating systems (electrical, electronic; hydraulic and pneumatic; digital and analogue sensors etc.)
- ✧ explaining anomalous results from laboratory instruments, experiments or trials (this role derives from familiarity with equipment and procedures arising from operation and or maintenance function)⁹
- ✧ writing up standard operating procedures or technical reports for the operation and maintenance of tools and instruments
- ✧ collecting data from instruments and experiments for analysis by researchers.

Design

They assist researchers with the design of objects, instruments and experiments to conduct scientific tests, or introduce new or altered production processes or prototypes. Design also includes advice on feasibility, where trades and technicians are involved in decisions such as: what instruments and materials can be used to test an hypothesis in an experiment; can a design from a scientist or engineer for a novel instrument or prototype actually be manufactured; is it best to make or buy an object; and, in relation to all of these decisions, how much will it cost? This design function was identified by researchers as a critical activity.

For trades and VET-trained technicians this activity is a function of their formal training. Design of equipment and systems and 3D software programs and technical drawing are prominent elements of diploma-level courses in particular. Design is also a function of experience in practical problem-solving; facility with tools and instruments; and knowledge of materials, their properties and performance characteristics.

Linking R&D to production

In those sites where R&D and commercial production facilities are co-located, which applied to all of the private sector sites in the sample, trades and technicians involved in R&D could be important in transferring R&D results to production, for example, installing modified equipment to produce a new product range and training operators in its use.

Occupational health and safety

An unanticipated role was applying safety rules and regulating access to dangerous environments and materials. OH&S is not only a central element in VET training of trades and technicians; it is also an important industrial relations issue.

⁹ A manager of a materials science research facility explained this role especially well: 'It is very important for us to be able to understand why a particular experiment has failed. The unexpected results are sometime perplexing. Often their [technicians'] insights are because they have 1–2 decades working with this sort of equipment and undertaking many different sorts of tests. Their suggestions about why a particular composite has failed are very helpful. This is generally across the board—not just one or so examples.'

Teaching

Within universities some trades and technicians are involved in teaching undergraduate lab classes and assisting postgraduate students to use equipment, interpret results and assist with the design of experiments or projects.

Importance of trades and technicians role in R&D

When asked whether ‘trades and technicians make an important contribution to R&D’, 90% of researchers said ‘yes’. Those who responded ‘no’ were in firms whose innovation was heavily dependent on advanced science inputs and who employed few VET-qualified technicians.

There was also strong agreement that, almost without exception, these contributions are made after the initial conception of the scientific or commercial problem that is the object of R&D activity has occurred and/or just after a decision has been made by a scientist, engineer or client to proceed with the R&D activity. The timing of this involvement reflects important differences in terms of hierarchy and authority across the principal occupations involved in R&D. Trades and technicians, almost without exception, do not have the authority and autonomy to initiate an R&D project.

Trades, technicians and researchers are agreed that there is a clear demarcation in terms of the role of researchers in the R&D process. First of all, researchers, with a science or engineering background, are responsible for the original conception of an R&D project consistent with the broad research parameters set by the R&D organisation. The researcher has to clearly specify the objectives of the project and the scientific or engineering principles that underpin it. Second, researchers are responsible for management of the budget and selection of personnel to be involved.

Training for trades and technicians

Virtually all trades and technicians possessed post-school qualifications. (Only one person of the 71 trades and technicians interviewed was not formally qualified). Eighty-six per cent of all entry-level qualifications were VET-level qualifications, ranging from certificate III to diploma. The other 14% were overwhelmingly science degrees. There was also a high level of participation in post-entry-level training, with 68% of all trades and technicians acquiring higher formal qualifications. Again almost all of these qualifications (77% of all additional qualifications attained) were VET-level qualifications, mostly at the diploma level.

There were some distinct patterns in participation in post-entry-level training across the broad occupational groups. Participation in post-entry-level training is common for people whose first qualification was a certificate III gained through a traditional apprenticeship, with 74% acquiring an additional qualification. However, participation in university education is very uncommon. (Only one of 31 such workers also acquired a degree.) In contrast, it was more common for technicians whose first qualification was at the VET level, but who had not done a traditional apprenticeship, to acquire a degree. (About 36% did so.) It was even more common for technicians with an undergraduate degree as their entry qualification to attain postgraduate qualifications. (About 55% did so.)

Another important empirical finding is that respondents in the sample are much better qualified than the broader population of trades and technicians in Australia (tables 6a and 6b). The table shows that nearly one-third of the total population of technician and trade occupations are without a post-school qualification, and for the nearly 70% of all employed trades and technicians across Australia who do have a post-school qualification, their highest qualification is a certificate III–IV. For the sample, on the other hand, just 23% have a certificate III–IV as their highest qualification, with just over 30% having an advanced diploma or diploma. Almost 100% of the sample has some sort of post-school qualification.

Table 6a Proportion of sample and total employed technicians/trades with a post-school qualification, Australia (%)

Post-school qualification	Sample	Total Australia*
With a post school qualification	98.6	68.2
Without a post-school qualification	1.4	31.8
Total	100	100

Note: * As of May 2006.

Source: ABS (2007, derived from table 12).

Table 6b Distribution of qualifications for those with a post-school qualification in the sample and total employed trades/technicians, Australia (%)

Qualification	Sample	Total Australia*
Postgraduate degree	8.6	1.2
Graduate diploma/graduate certificate	1.4	1.0
Bachelor degree	12.9	8.0
Advanced diploma/diploma**	31.4	10.4
Certificate III/IV	22.9	69.8
Certificate I/II	0.0	7.1
Certificate nfd***	22.9	2.4
Total with a post-school qualification	100	100

Note: * As of May 2006; ** Also includes associate diploma; *** Certificate not fully described. For the sample all those with a certificate nfd had in addition a minimum of a certificate III qualification.

Source: ABS (2007, derived from table 12).

There are two distinct trends here which require a tentative explanation. Firstly, why do workers whose first qualification was at the VET level have a strong propensity to choose further VET rather than university studies when undertaking further formal training? Secondly, why are trades and technicians in R&D so much better qualified than their counterparts outside R&D? These questions were not explicitly asked in the survey but a number of possible causes were identified.

In relation to the first question, the great majority of trades and technicians stated they liked their current role because they had found a workplace which engages and develops their skills and encourages their involvement in problem-solving; they also find the projects they work on to be inherently interesting and important. Most also expressed a desire to avoid management responsibilities. However, some trades and technicians noted that they would have to assume these responsibilities if they sought a promotion to a position requiring a university qualification. Respondents were also on average mature-aged and presumably with financial and family commitments, making it more difficult to devote time and money to university study. It is important to note that the low progression of trades-based workers into university was not raised as an issue, either positively or negatively, by researchers. Given the important role attributed by researchers to trades and technicians in R&D, it was plausible that researchers required experienced people in these positions.

In relation to the second question, trades and technicians stated that the skills and knowledge they acquired through formal training are essential to performing their present duties in R&D. This reflects the advanced technologies encountered in some R&D sites and the broad range of different technologies that many R&D workers encounter over the course of their working life. Close to three-quarters of trades and technicians identified specific technological changes at their workplace in the past five years that had affected how they do their jobs or had required them to develop new skills or knowledge. Only two of 71 trades and technicians stated that their formal qualifications were not useful in their current job. (Both were in unusual circumstances.) The great majority of researchers (16 of 17 who answered the question) also agreed that the acquisition of formal qualifications by trades and technicians was important in an R&D environment. Fifty-eight per cent

of trades and technicians who had acquired further qualifications stated they had done so specifically because of the R&D work they were doing. At a more mundane but equally important level, in most of the workplaces visited, possession of post-entry qualifications was a prerequisite, or a strong expectation, for promotion into technician positions of a higher grade.

It is important to note that none of the 103 respondents raised the need for a separate qualification or a different stream of initial training for workers intending a career in R&D.

Notwithstanding the high rates of participation in formal VET, there were also criticisms of the ability of the training system to meet the needs of an innovation-intensive workplace. Firstly, some trades/technicians and researchers were critical of what they perceived as a lack of underlying theory or knowledge in current training.¹⁰ One manager of a private pharmaceutical laboratory explained that:

The person has to be able to think and to be able to learn. With VET trained workers I think the theory is actually extremely important. For example, I wanted our lab tech to be able to make calculations and decisions based on a fundamental rationale. It worries me that there seems to be a trend just to go in to assess whether 'you can do this here and now'. They need to understand why and are capable of this aspect ... There is no substitute for having grounding in logics like cause and effect and in the necessary calculations that can justify a decision.

A manager of a large central engineering workshop said:

[I] prefer the old modular apprenticeship system—do not like self-paced CBT as they are not learning deep trade skills and not learning why.

A second problem was the ability of TAFE to keep up to date with new technology. To some extent this may be an inevitable outcome of the more advanced technologies employed in some R&D sites. These results are, however, consistent with other research which has found that there are significant impediments to TAFE maintaining the technical currency of equipment and staff (Toner 2005). Managers were, however, sympathetic to the constraints on TAFE as indicated by the following comments:

TAFE is not supported financially to keep up to date with new technology.
(Manager of a large central engineering facility)

TAFE is doing their best with the budget. TAFE are always going to be behind technology but the training gives them a foundation.
(Electronics engineer defence research)

There were also positive comments about the current VET system: there was support for the pre-apprenticeship system; a young person recently graduated with a diploma in mechanical engineering liked the self-paced system as it enabled him to complete his diploma early; and a biotechnology manager commented favourably on the flexibility of the VET system, which enabled his firm to select training topics for lab technicians more relevant to the R&D they undertake.

While there are comparatively high rates of participation in formal VET, the VET system is not the primary means used by trades and technicians to keep up to date with new and specific technologies. Sixty-one per cent of respondents had participated in training courses in the previous 12 months. The principal means used to learn these new technologies were short courses delivered by equipment vendors; training and learning from other workers on site; and self-teaching through

¹⁰ The recent Department of Education, Employment and Workplace Relations—Australian Industry Group (2009, p.4) study also identified the importance of 'industry specific foundational knowledge' for the implementation of emerging technologies. It provided examples 'such as geology and physics knowledge for the geothermal energy sector; knowledge of the properties of CO₂ in the carbon capture and storage industries; and materials science knowledge for advanced composite materials as well as high level information technology and technical skills in the field'. A broad knowledge base for VET workers was also identified as crucial to ensuring the capacity of workers to adapt to rapidly changing technologies (Australian Industry Group 2009, p.20)

manuals or the internet. This result is not surprising, given that the 'technologies' involved were largely specific proprietary tools (either software or hardware), where the vendor often provides training as part of the sale.

Work organisation

It was found that work organisation systems are critical in mediating the quality of the working life of trades and technicians in R&D and, arguably, the performance of R&D. When asked to identify aspects of R&D they 'like or find satisfying', trades and technicians, with few exceptions, identified a range of attributes, mostly related to work organisation. These include: variety of work; engagement in problem-solving; access to training and learning new skills; exposure to new technology; higher job security (at least in the public sector and larger private firms); and work organisation systems and colleagues who treat them with respect and encourage their active engagement in innovation. The majority of respondents stated they were involved early in new R&D projects; had 'some control over the allocation of work'; felt 'encouraged to contribute to innovation'; and believed their 'skills and capabilities were recognised and utilised'. Trades and technicians self-select to enter and, more especially, to remain in R&D because of these attributes. This conclusion is supported by the negative attitude of current VET-trained R&D workers who had previously worked in non-R&D workplaces, such as production and/or maintenance, to the prospect of returning to such workplaces. The unattractive aspects of their previous work included: a dislike of routine; lack of autonomy; dis-engagement from innovation; and the intense pressure found in a production or maintenance setting to 'get the product out', sometimes at the expense of quality.

Respondents identified a number of work organisation attributes they believed contributed positively to the performance of R&D. Firstly, the differences and complementarity of skills and knowledge across scientists, engineers, technicians and tradespeople are explicitly recognised, and work is organised in small teams to take advantage of these complementary skills. Teams are either permanent; that is, devoted to projects in a particular technology specialisation, or are ad hoc project-based teams formed to meet specific needs. Secondly, job security and lengthy job tenure resulted in the accumulation of enormous experience in specific technologies by team members. Job security also had the advantage, as explained by a mature-aged female electrical apprentice, that workers did not have to worry about sharing information, which could otherwise result in 'someone trying to take your job'. On the other hand, researchers noted that a 'static workforce' can result in complacency and 'group think'. They suggested that teams need to be supplemented by a certain inflow of new skilled people who have experience of other technologies, organisations and ways of solving problems. Thirdly, team members work in close physical proximity to facilitate ready exchange of information and problem-solving. Close proximity means people being able to meet and make quick changes in designs; to instantly see and handle a prototype; and to immediately test the prototype with the designers and/or maker present to see how the prototype performs and how it might be improved. Finally, all members are encouraged to actively contribute to early concept planning, iterations of designs and development of prototypes.

The following example from a fitter machinist outlines clearly the benefits for both the researcher and the tradesperson of close collaboration and proximity:

some engineers come down and ask about whether a design is possible in our opinion, particularly things like size limitations, scale issues. Some of the engineers always or at least regularly do that, this saves everybody hassle as it eliminates designs from the system that can't and won't be done. If an engineer needs to know if it is worth pursuing a particular path with a design he will sometimes ask us to knock something up, if it's only going to take 20/30 minutes, then he can pre-test his idea. Once again, saves a lot of unnecessary time wasting later.

However, many respondents were also critical of the work organisation at their R&D workplace. Firstly, positive outcomes appeared only in part to be the result of well-planned and well-

implemented organisation-wide systems. They were often the result of good practice on the part of individual researchers and/or good practice within small teams. As noted by many trades and technicians, too often good work organisation practice was the result of the ‘personality’ of particular researchers. Secondly, a large minority of trades and technicians were critical of the ‘separation of conception from execution’ or their limited engagement in the ‘R&D process’. Either they were already quite engaged in problem-solving and design but wanted much more involvement, or they felt their input was simply not encouraged.

Overall, the majority of workers felt engaged in the innovation process (despite most wanting much more involvement). The separation between conception and execution noted above was caused by inadequate communication between researchers on the one hand and trades and technicians on the other. The interviews with trades and technicians revealed that there are some researchers who do not understand the importance attached by trades and technicians to their engagement in the R&D process, while others considered more and earlier involvement in initial planning and design would improve the efficiency and quality of outcomes. Another factor leading to the separation of execution from conception is the increased reliance, especially by public sector research agencies and higher education, on outsourcing work previously done in house by trades and technicians.¹¹

Conclusion

This chapter provided a brief account of the concept and measurement of innovation and some of the evidence on the role of trades and technicians, and the vocational workforce more broadly, in the innovation process. The evidence was drawn from a number of sources including the key processes of innovation identified by the innovation studies literature; the official definition of the skills, knowledge and functions of trade and technicians occupations; official surveys of innovation activities in firms; ‘matched plants’ studies; and research relating differences in the composition of exports to national differences in workforce skills. It also drew selectively on a recent survey on the role and contribution of trades and technicians in R&D labs. These sources are clearly diverse in terms of their subject matter and methods, but, importantly, all point to the significant role of these occupations in the innovation process.

This account also points to a significant gap in the research. With the exception of the recent survey of R&D labs, there are few other studies that examine in detail the specific contribution made by trades and technicians to innovation in particular industrial settings. This is potentially a fertile field for research.

The empirical findings in this chapter should also contribute to important contemporary VET policy debates. Firstly, on the issue of ‘skill under-utilisation’ and ‘skill deployment’ the findings highlighted the critical role of work organisation in determining how skills and knowledge acquired through formal training and work experience are actually used in the workplace. In particular, it identified specific practices that encourage or discourage the use of these skills in innovation. This suggests that for policy-makers the focus should not simply be on the quantum, or number and level of VET graduates, but equally on workplace practices that more fully use the potential created by the education and training system. Secondly, it found that in innovation-intensive workplaces tradespeople and technicians are expected to have, and to develop, a ‘theoretical understanding’ alongside practical skills. There is also strong resistance by VET-trained workers and research managers for the VET system to emphasise the latter at the expense of the former.

The evidence in the chapter also suggests that, given the large share of the total workforce comprising trades and technicians and their apparently significant contribution to innovation, there

¹¹ According to the Productivity Commission (2007, p.36) ‘direct funding of Australian Government research agencies has barely grown in real terms over the past 25 years’. It increased by just 1.1% in real terms over the last 25 years. As a result government support for public R&D labs halved as a share of GDP over the same period.

should be much greater formal recognition given to the VET system in science and technology policy and in public forums such as national and state science and innovation councils. This could assist in increasing resources to improve the capacity of the VET system to keep up to date with new technology and in better integrating VET and university training.

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VET and the diffusion and implementation of innovation in the mining, solar energy and computer games sectors

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This chapter presents research exploring the relationship between the education and training system, especially vocational education, and innovation in three sectors: mining, solar energy and computer games. Although we are aware that there is a relationship between skills development systems and patterns of innovation in industry, few details are known. Our cases were selected to illuminate the range from a stable sector with strong linkages to VET (mining), to a sector selling novel products but based on a stable knowledge base (solar energy), to a sector with a new and rapidly changing knowledge base (computer games). Our analysis was predominantly based on 66 interviews but also used available statistics and research literature.

A key finding is that each of the three sectors had quite different skill development dynamics, largely driven by the sector's commercial imperatives. Firms require a specific set of skills and structure their skills for innovation around firm organisation and processes. In the three sectors we examined we saw little evidence of individuals possessing generic 'innovation skills'. The actual skills used in innovation by individuals were typically learnt on the job, but based on what was learnt formally.

From the point of view of innovation we conclude that the formal education and training system (especially VET) should focus on providing people with the core skills for their vocation and the ability to learn and adapt.

Introduction

This chapter,¹ which summarises a larger report to be published by NCVER, presents research exploring the relationship between the education and training system, especially VET, and innovation² in three sectors: mining, solar energy and computer games. The report is one of the

¹ A summary of the report *VET and the diffusion and implementation of innovation in the mining, solar energy and computer games sectors*, by R Dalitz, P Toner & T Turpin, NCVER, Adelaide, forthcoming.

² This study uses the *Oslo manual* definition of innovation: 'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations' (OECD 2005).

first such studies on this topic and in this chapter we focus on the empirical results, main findings and policy implications from the report.

Economic development is driven by innovation; workforce skills underpin innovation, and innovation drives skills development. Diverse dynamics in sectors and firms arise from the various modes of innovation used by sectors and firms, including product, process and organisational innovation.

The literature on economic development shows strong linkages between innovation systems and skills development systems (Landes 1969; Freeman & Louca 2001; Perez 2002) and we also know that certain types of skills development systems support certain modes of innovation to create ecosystems that reinforce patterns in competition and skills (Finegold & Soskice 1988; Keep & Mayhew 1999; Prais 1995). This literature indicates that patterns of innovation and skills change over time, along with the industrial structure of economies. Thus ‘innovation and training in modern economies are inextricably linked’ (Warner 1994, p.348). Understanding the specifics of the relationships between education and training systems and innovation in particular sectors can assist policy for both skills development and innovation.

Despite the overwhelming agreement on the importance of workforce skills for innovation, there ‘is little systematic knowledge about the ways in which the organisation of education and training influences the development, diffusion and use of innovations’ (Edquist 2005, p.185).

Correspondingly, we know little about how innovation influences the education and training system. This study aims to improve our understanding by answering the following questions:

- ❖ What is the role of VET qualifications and ongoing vocational training in the diffusion and implementation of innovations?
- ❖ How does VET keep up to date with innovations in technology and its methods?
- ❖ How do workers learn the skills needed for working with new technology and its methods?
- ❖ How does the VET system affect the abilities of individuals and firms in generating, dealing with, and diffusing innovations?

Our case selection and the case study approach are designed to explore the issue of the interrelationships between innovation and education and training. Our selection of case studies was based on the current point at which each sector sits in its life cycle: mining is a mature, stable sector; solar energy is a new sector but is based on a mature sector (electricity generation and distribution); and games is a new sector entirely. The case study approach itself is well suited to exploratory research that aims to elucidate relationships rather than measure the strength of known dynamics (Yin 2003). The data were primarily collected through interviews, although statistics and available documentary evidence were also utilised. We conducted 66 semi-structured interviews with teachers, firms, and a range of other stakeholders across the three sectors, as shown in table 1.

Table 1 Respondents

	Mining	Solar energy	Computer games	Other	Total
Firm	12	10	11		33
Teacher	7	6	9	1	23
Other	3	6	2		11
Total	22	21 #	22	1	66

Note: # One respondent was both a firm and a teacher.

Our research found that the relationship between innovation and the education and training system was quite different for each of the sectors and, for each, the formal and informal education and training systems carried out distinctive roles. The formal education and training system is run

according to government policy and generally aims at producing Australian Qualifications Framework (AQF) qualifications. The formal system, for each vocation, teaches fundamental knowledge and skills important to the ability to learn, to adapt to change, and to be creative. Informal education and training (whether undertaken on the job, through specialised training or through experience) leads to the specific skills used in innovation, but is usually based on the fundamentals learnt in formal education and training. Each firm's strategy, competitive position and consequent innovations drive its skills requirements; accordingly, firms develop idiosyncratic capabilities and ways of working that lead to firm-specific informal and formal training regimes. We did not find generic innovation skills³ in any of the sectors; rather, we found that workers with stronger fundamental knowledge and skills in their vocation were more effective in innovation. In keeping up to date with innovation, teachers used their personal networks, suppliers, publications, conferences and web-based media, with differences by sector.

Mining

The mining sector is large, diversified and complex and Australia's largest export sector. The sector's firms range from some of the world's largest, through to standalone mines. There is also a wide array of technology suppliers, consultants and contract miners. Over the last decade the mining sector has experienced a major boom, with demand exceeding capacity. This has meant that creating capacity, through new mines and extensions of existing mines, has been the main focus of firms, rather than innovating to improve ongoing operational efficiency.

The mining industry invests 2.3% of gross wages and salaries on training, more money per employee than any other industry, and 96% of firms provided some form of training in 2006–07 (NCVER 2008). There is relatively high job mobility in the mining industry, with 27% of workers having been in their job for less than a year compared with 21.3% for all industries, and up to 85% turnover reported (National Resources Sector Employment Taskforce 2010). The mining industry faces a current skills shortage and is projected to have a shortfall of over 60 000 suitable employees in the near future (National Resources Sector Employment Taskforce 2010). The 2006 census records that, in the mining sector, 17.7% of the workforce are university-educated, while 39.1% are VET-educated (ABS census data and own calculations).

Our research focuses on mine operations, where the VET system is most important and most utilised. We have not studied exploration or the construction of mines, the other major mining activities. Respondents include mining company training managers and trainers, SkillsDMC,⁴ private registered training organisations and universities, industry bodies, suppliers and contract mining companies. The skills involved are largely those relating to engineering (university-qualified), the qualified trades and operators. Operators have competences in areas such as dump truck driving, the operation of specific mining and extraction equipment and so on. Innovation in operations occurs primarily through changes in equipment but also in operational methods. Operators are trained in the use of new equipment and on occasions in techniques to improve work productivity.

The VET workforce is split into two areas in mining operations: traditional trades and operators. Although the management of trades apprentices and the ongoing training of licensed tradespeople consume a great deal of money and time, in terms of meeting government and TAFE requirements, the companies' attention is more on operator training. This is because the mining companies can rely on the external VET system and specialised training providers for trades worker training.

³ The idea of 'innovation skills', common, general and transferable innovation skills that are applicable to all, or most, occupations, has been promoted by government, employers, unions and VET policy-makers. There are specific units of competency (BSBINN501A: Establish systems that support innovation) and instructions on how to incorporate innovation skills across any training package (IBSA 2009).

⁴ The industry skills council for the civil construction, mining and quarrying sectors.

Training managers reported that the traditional trades just need a top-up in mining-specific training to become suitable for work in mines, which usually takes place through specialised private suppliers. As the training manager of one of the largest mines commented, although trades training takes up a large proportion of his time, ‘you just cannot refer to training in our business and the relevance of the maintenance trade and apprentices, it’s just such a small drop in the bucket of what we do, it’s just about irrelevant’. Thus, while the mining companies train some trades workers, they are more than happy to employ trades-qualified people from other industry sectors because the fundamental knowledge and skills are the same, regardless of sector. Operators, however, require skills that are job- and equipment-specific to mining and which reflect the firm’s structure, practices and innovations. When asked, SkillsDMC, trainers and training managers alike stated that, in terms of the underlying dynamics driving training, there was little difference between the various modes of mining, underground and above ground, or in the types of mines, coal and metalliferous, or even in specific jobs.

Thus the research didn’t attempt to focus on one particular type of mine or job. Operator training aims to ensure that workers can safely operate specific equipment. Safety goes beyond competent equipment operation and includes working in confined spaces or at heights and reducing dangerous incidents. Training is aimed at the specific competences required for certain roles, which correspond to the competences in the training package. Often associated with attaining a specific competence is a ticket or certification that legally allows that person to operate a certain type of equipment or perform a specific job. As a training manager said, ‘you have got to have a national ticket for operating a crane, or for operating a forklift or an elevated work platform. So we will go to a private training provider to train people, but that private supplier must be an RTO and must be able to issue the national work safe license.’ All respondents said that the mining companies care about specific competences and the associated tickets that workers have, but have little consideration for qualifications under the Australian Qualifications Framework (AQF). Once a worker has a ticket/competence and experience in a job, they are generally accepted throughout the mining sector as competent. According to all the larger miner respondents, training workers to attain qualifications is only done to assist in retention or because supervisory roles legislatively require certain qualifications.

Most operator training is undertaken through the mining companies themselves and specialised private training providers. This is driven by an array of factors, most particularly that the knowledge and capital equipment required for training largely resides within the mining firms themselves. Furthermore, the mining companies want training to be on site (often in remote locations), and with flexible timing to ensure that production is not disturbed. A senior mining training manager said of TAFE:

There’s no way they can compete with the mining industry in salaries and remuneration for their staff. Therefore, they simply cannot provide the service, regardless of the programs they’ve got ... The second thing is our operations run 24/7 and 52 weeks a year, we do not shut down. We need to train people on back shifts, night shifts, over weekends.

The dynamics discussed above lead to the training of mine operators, and training in mines in general, to be a semi-separate system from the general VET system, especially TAFE. Combined with a focus on individual competences, this means that the providers of education and training in mining work according to a logic different from the qualifications focus of traditional VET.

Although most of the competences for mine operators relate to the operation of pieces of capital equipment, such as trucks and machines for mining and processing ore, and infrastructure such as conveyor belts, trainers consistently referred to the need to teach ‘theory’ before operators are considered competent. A trainer of dump truck drivers explained ‘theory’ as being about how the trucks worked, how to drive them in mines and the logic of mining operations. Although ‘anyone can drive a car and trucks aren’t much different, easier in some ways’, the drivers should know how to operate the trucks to maximise productivity, reduce maintenance and improve safety. As

operators move on to more complex roles and pieces of equipment, they gain more competences and a better understanding of how the mine works, in both abstract and practical senses. This requirement for fundamental knowledge and skills was necessary: equipment is constantly being changed and introduced, and people change jobs and encounter new equipment.

The amount and type of innovation in a mine varies greatly by site. Some mines are one-off projects, with limited innovation, since the mine design itself specifies equipment and methods for the mine's duration. Some mines are large-scale and long-term operations, offering a greater incentive to improve operations, potentially allowing internal learning and transfer of best practice. It could be expected that managerial attention would be on continual improvement, with training a vital part of that; however, this is rarely true for the cultural and labour market issues reasons discussed later. Both training managers and supplier trainers explained that innovation mainly occurs through new equipment and follows a structured training pathway as follows. Mining company engineers and lead operators select a new piece of equipment. As part of the purchase the equipment producer develops training materials and provides training to key operators and mining company trainers. These key operators and trainers then train other operators and the equipment becomes embedded into ongoing operations. As discussed below, the mining training package assists the coordination of skills development in relation to innovation and labour markets because the individual competences identified in the training package directly correlate with the skills and tickets required to do specific jobs.

Most mines are either run by or have large numbers of contractors. These contractors receive the standard safety induction and site training for each mine. However, training to improve operational performance is the responsibility of the contract company. Contract miners said that many mining companies prefer the cheapest tender, which limits the ability to train, while contractors typically have incentives for improving performance in operating the mine. Thus the contract mining companies essentially have two routes, a cheap no-frills model, or a model of efficiency and improvement. Most contract miners use their own equipment, although mines often have some equipment operated by contract labour. The cheap route involves employing less expensive labour, usually less experienced people, with only the minimal training, as required by legislation, regulations and contracts. The other route for contract miners involves employing and trying to retain good workers, and continually developing their productivity. In general the cheap contractors are used in smaller and more marginally viable mines, with the more expensive contractors used by the larger, more viable mines. Contractor workers are often poached by mining companies, which a training manager at a large mining company claimed was a deliberate ploy because of its low cost and risk. This means that contractors face a problem: if they develop their people 'too' well, they are likely to lose them to mining companies with the ability to pay more.

Once a mine is established, safety becomes the paramount driver of training, because it is legislatively required that mines operate in a safe manner and training is seen as important by the regulator. Although each state or territory and each type of mine have slightly different specific requirements in relation to safety, there is generally a direct responsibility for the mine site manager to be accountable for safety at that mine site, and the mine's licence to operate is reliant on safe operation. Thus training is not seen as a corporate activity aimed at improving competitiveness, as, for example, in Toyota; it is a legal necessity during which some improvement activities can be achieved as a secondary consideration. This leads to most training being at the mine rather than the corporate level. For example, in a large coal miner with several mines, all trainers are employed at specific sites, with the corporate human resources manager playing a coordination role. Training is therefore typically fragmented and often focused on regulatory issues rather than on innovation. Because this regulatory driver tends to overwhelm a focus on innovation in operations, training is often indirectly linked to innovation through new technology and a change in methods.

The rationale for why most companies are not strongly focused on using training to improve mining practice is multifaceted—it is determined by cultural, labour market, and commercial

factors. Culturally, mining companies are focused on technology and equipment, and have a 'buy in' mindset. The focus on technology and equipment leads to a diminution of attention to improving workers' skills. This cultural focus is logical, given the importance of finding and building mines to the success of any mining company. Reinforcing this is the 'buy in' culture, where the mining companies tend to buy in things they do not possess, especially skilled people. This is reflected in data from the ABS innovation survey, which provides information on the innovation activities of firms, including skills issues. The ABS reports on 16 industries, and we ranked the industries by the intensity of firms using various sources of labour for innovation. On this data item, regarding the sources of labour for innovation, mining ranks first in terms of using contractors, and second in employing new people for innovation, while being fifteenth of the sixteen industries for using internal people for innovation (ABS 2010). Some respondents in the mining companies are frustrated by this culture because it means that the company rarely invests in developing resources, whether technological or human resources.

Culturally, the 'buy in' mentality means that training for innovation is seen as unnecessary, as long as the company can acquire suitable people through higher wages and/or better work conditions. Commercially, as the mining sector has insufficient capacity to meet demand, it is more important to create new capacity through new mines and extensions to existing mines than to improve the operations of ongoing mines. Management attention in operational mines is thus on production, with innovation and efficiency a low priority because prices are high enough to assure the profitability of even low-productivity mines.

Alongside this are the mining skills shortage and the fluidity of labour markets. Training people makes them more valuable to other firms, who then buy in these skills, boosting wages and disrupting the ongoing improvement associated with workforce skills improvement. As stated earlier, employee turnover is about 27% overall, increasing to 85%. Thus training beyond a certain standard can easily be considered as self-defeating, as operators move to more lucrative jobs. Larger mining companies 'poach' workers from mining contractors, smaller mines and other industries and import skilled labour. Some respondents said that they would import dump truck drivers, rather than training them up from scratch. It is difficult for people to enter the mining industry, due to the stringent requirements and the reluctance of mines to take on 'green' staff. The larger and better resourced mining companies prefer to employ already experienced workers, thus meaning entry of new workers is mainly through marginal mines and contractors. Finally, the boom conditions faced by most miners leads to the companies trying to increase production and simply 'get the good stuff out of the ground'. This means that, currently, the core to making profits is about finding and exploiting ore bodies rather than improving ongoing operations.

Respondents consistently used the training package developed by SkillsDMC as a template for training and assessing the competences of workers. SkillsDMC has representatives from all important stakeholder groups involved in the development of the training package, including industry bodies, mining companies, teachers, equipment suppliers, and contract miners. All stated that the training package accurately reflects the competences required to undertake mine operator jobs, and so training and career development are structured by the training package, allowing the creation of pooled labour markets. The training package is thus a central factor for training, labour markets, and regulatory issues, but is peripheral to innovation in itself.

There are many other actors involved in the relationship between the education and training system and the mining sector, such as the Mining Industry Skills Centre and the Mining Council, who provide research and advice about mining skills. These actors connect the various players and inform policy and the firms. However, the mining firms tend to operate as competitors in the skills arena, except in areas such as the provision of university education where sector-wide cooperative initiatives have been formed. The federal government has little presence in mining skills issues, except through SkillsDMC, and some state governments attempt to exert some influence, but have had limited impact so far.

Solar energy

The solar energy sector comprises the installation of, and electricity production from, solar, photovoltaic (PV) panels. The manufacture of PV cells is a minor activity in Australia and was not examined in this research project. Respondents included solar energy company managers, teachers at registered training organisations and universities, EEOz (the electrotechnology industry skills council) and industry bodies. Over the last few years the industry has grown rapidly, mainly driven by government incentives stimulating demand. These incentives have made the 'grid connect' area, where the solar cells produce electricity to put back into the main electricity grid, the major market area, and so the focus of research. Regulations drive training because only installations done by technicians with Clean Energy Council (CEC) certification are able to access the government incentives, and connection to the grid has to be done by a trade-qualified electrician. Government incentives led to a boom in the sector, increasing the demand for CEC-accredited people and licensed electricians and prompting the need for efficient operation.

Innovation in solar energy firms includes incremental improvements in technology and organisational innovation to reduce costs. The core photovoltaic technology (silicon on glass) has been stable for decades, and although there are many alternative technologies, according to all respondents, none is yet commercially viable. Other technologies in the solar energy system such as inverters have undergone considerable change, improving the efficiency of solar energy, that is, the percentage of energy from the sun's rays converted into electricity. This technological innovation is relatively easy to adapt if firms have good fundamental electrotechnology knowledge and the skills to understand the technology's implications and supplier materials.

The main current driver of competitiveness for solar energy firms is usually organisational innovation driving down costs. Much of the cost for PV installations is labour, leading to firms both outsourcing and insourcing electricians. There are three common ways to organise solar energy firms in Australia. In small-scale enterprises, an electrician cannot be kept working full-time, and so typically firms outsource. As firms grow larger, electricians can be employed full-time on the installation and connection of systems, which costs less than using contractors. However, a third organisational form focuses on sales and design while outsourcing installation and connection, which means that firms can rapidly increase in size, while limiting sunk investments. This organisational innovation means that there are incentives for individual electricians to gain CEC accreditation and undertake solar work, either as the lead or outsourced provider. Furthermore, it is advantageous for the larger firms which use outsourced installation teams to have their own professionals undertaking design and sales, while overseeing the skills and costs of their outsourced installers.

According to the solar company respondents, household installations usually use modular technology, user-friendly design software, small autonomous teams of low-skilled labour and an electrician. Even though 'about half an hour's work really requires the electrician's skills, but they have to be on site anyway, [so] you use them to do the lifting and installing', according to a solar company manager. Thus, the regulatory requirements and the nature of how the work is done lead to a focus on qualified electricians. Although CEC-accredited designers and installers must sign off work, many companies used non-CEC accredited electricians to do the work. This has led to many electricians entering the sector as contractors, some working with a firm with CEC-accredited staff or gaining their own CEC accreditation. Large installations are usually one-off and require a higher level of skills and knowledge to cater for the peculiarities of the installation and issues resulting from their sheer size, but currently this category represents a small market segment. Many firms have improved their efficiency through organisational innovation, such that the general manager of one solar energy firm said that 'some competitors have managed to get two or even three installations per day, where it used to be one'. This increase in efficiency lowers costs dramatically and requires careful design and management, including a great deal of on-the-job training.

In terms of formal training, the two routes are, firstly, undertaking the Certificate III in Renewable Energy, or better; the alternative is for electricians to complete a short course directly addressing the requirements of Clean Energy Council accreditation. These courses provide the necessary fundamental knowledge and skills to perform solar energy work, as well as allowing CEC accreditation. Design and installation require electrotechnology theory and an understanding of the logic behind grid connection; they also require specialist areas of expertise not typically taught in an electrician apprenticeship. Although it is mainly electricians undertaking these courses, some non-electricians also do them. The courses are typically taught through a TAFE or registered training organisation associated with an industry body by teachers currently working in the solar energy industry, which enables knowledge of current industry practice and products to inform the courses. The teachers, who also work in industry, said that they gained useful knowledge and contacts from teaching the courses.

Some electrician apprenticeship teachers are currently undertaking the established renewable energy courses themselves so that they can teach this to apprentices.⁵ In almost all instances the teachers use training materials developed originally by the Brisbane North Institute of TAFE, which provide good basic coverage of solar content. To teach these courses the registered training organisations have been obliged to acquire the full range of equipment and products for solar cell installations, and so have up-to-date equipment and contacts with industry. Once the knowledge and skills for designing and installing solar cells have been learnt, all that is needed for most designers and installers are on-the-job learning and the manuals provided by equipment suppliers.

Firms develop practices to improve their efficiency and effectiveness, as discussed above, and pass them on through internal training. Most firms said that they conducted training occasionally, with the main method of internal training being on the job with an experienced worker. Supplier manuals for new technology are also used, but as one firm respondent said ‘they aren’t much use, you learn more playing with it to work it out’. This ongoing learning is based on people’s fundamental knowledge of electrotechnology.

The solar energy sector is reliant on the widespread availability of people with good basic electrotechnology knowledge and skills. When interviewed, the regulators said that they deliberately ensured that electricians have a broad understanding of electrotechnology theory, which means the electricians can learn how to work with technological innovations and across a broad range of occupations. Because the regulators license electricians to practise they have great influence over the development of training packages and qualifications. The other players we talked to, EEOz, the unions and employers, all support this approach of focusing on general, rather than job-specific knowledge and skills. This means that electricians in the solar energy industry are more ‘jacks of all trades’ than specialised workers, only requiring a relatively small addition to their existing competences in areas such as low voltages, inverters, and the design of installations. In this way the solar sector has access to a large labour market of skilled workers who have been relatively easily trained to high standards, rather than the sector having to develop a pool of skilled labour from scratch.

The links between training package development, teaching and industry are through the general mechanisms used in VET in the electrotechnology area and some renewable energy-specific organisations. The electrotechnology area has strong and well-established linkages between industry, industry skills councils, training providers and public bodies, such as regulators. The central aspect to this is the electrician apprenticeship system, because only licensed electricians are allowed to perform many electrotechnology tasks, including the connection of solar systems to the grid. There are also some solar-specific organisations: the Clean Energy Council and the

⁵ This will probably make the link between teaching and industry less close as most electrician apprentice teachers are full-time professionals, and renewable energy is a minor part in the entire apprenticeship. However, this was only just occurring during the research, and so the effects of the inclusion of renewable energy into the core of the electricians’ apprenticeship are not yet clear.

Appropriate Technology Retailers Association of Australia (ATRAA). Renewable energy generation has moved from being a small activity of minor importance to the major electricity utilities, to a current issue of great importance and vital future concern. Renewable energy subjects have for the first time been included in the latest release of the electricians training package, which will be widely taught in 2011. This moves the entire renewable energy area into the established heart of the VET electrotechnology system.

Computer games

The computer games sector involves the development of computerised interactive entertainment. Globally, it is a larger industry than the film industry and was growing rapidly until the Global Financial Crisis of 2008. The games industry in Australia is comparatively small, with 49 commercial operations employing 1431 people in 2007 (ABS 2008). The core of the sector in Australia comprises firms that develop games for the foreign publishers who own the brands, characters and events that constitute the intellectual property (IP)⁶ of a game. Alongside this, in areas such as defence and mining there are ‘serious games’, where the purpose is not entertainment per se, but where games are used in organisations for the purposes of setting and achieving goals. Games skills are also used in areas such as marketing, films, training, real estate and urban design. People who undertake games courses therefore have a much broader labour market to select from than simply games firms. Our respondents included games firms, Innovation and Business Industry Skills Council,⁷ private and public registered training organisations, universities and industry associations and bodies.

The computer games sector is continually evolving, with transformations every decade or so driven by changing demand and technology. In the 1980s firms had small multi-skilled teams producing relatively small and simple games. By the 1990s games had become larger and more sophisticated, the division of labour had increased and the growing market allowed specialist games styles for particular customer groups. In the 2000s large complex games dominated sales, with sophisticated platforms and globally segmented demand, by type of game. Now in 2010 there is a huge variety of games types—very large sophisticated games, smaller versions of the large games, and a wide array of small games for mobile phones and the internet. In 2010 funding issues associated with the GFC are driving a downturn of at least 30% in industry size, with several respondents expecting their firms to fail shortly after our interview.

The current array of games basically means that there are three categories of game companies: large games producers with extremely specialised teams and a hierarchical management system; an array of medium-sized companies with moderate specialisation; and small companies with multi-skilled workers and a flat management structure. The work of the large- and medium-console game companies mostly encompasses developing games for the publishers who own the intellectual property (IP) the game is based on. This means that the Australian games companies have to continually bid for new projects rather than developing a series of games they own themselves. The large-console games typically have budgets of \$30–100 million and teams of 60–200 people working on them. The large teams lead to a high degree of specialisation in skills, often with command and control management, with large numbers of ‘pixel monkeys’ simply producing graphics designed by a small core of managers and designers. Much of the innovation that occurs in large firms is driven by internal teams of experts developing company-specific games engines and software tools that allow the company to move beyond the capability of the publically available technologies and tools.

⁶ Examples include Formule 1 racing, various football leagues, and James Bond.

⁷ The relevant industry skills council.

The medium-console game companies typically work on projects worth \$2–10 million with teams of 10–50 people. The division of labour is less pronounced, especially with less art work due to less powerful games consoles. There is a flatter hierarchy, typically with key experts driving innovation, but not dedicated teams. Phone and internet games are a recently emerged market segment, with low budgets and teams of between one and five people. Workers have to multitask and management structures are flat. This segment has quite different competitive dynamics, as purchases are driven by the fun of the game and word-of-mouth recommendations rather than ownership of valuable IP, such as a brand or well-known character.

Innovation in the games sector is project-driven, whereby the firm has to adapt to new methods, technology and tools for each project and to develop its own innovations to gain other funded projects. Every two to four years major changes occur in core platforms and software, with constant upgrading. Many other programs and tools emerge, find favour, and then disappear over time. Moreover, when games companies acquire a project they determine what the final technology on its launch will be and freeze the project at that technology. Therefore firms will vary from leading edge to falling behind, in terms of technology and skills requirements, depending on where in the cycle of games development they are presently located. Companies are thus idiosyncratic in terms of the technologies they use and skills they require. This means that a games student cannot learn all of the available tools and techniques and must have the capacity to continually update skills.

Beyond the need to adopt and adapt publically available technology and tools, games companies have to develop internal ways of extending their technology to ensure that they maintain competitiveness in selling their services. Developing their own tools and tricks requires high-level skills and creativity, meaning that games companies are always seeking exceptionally talented individuals. Typically, internal learning occurs through mentoring or informal group exchanges, with a lead person developing or learning something new, then passing it on.

Games companies rely on employees having the fundamental programming or art skills as the foundation for further learning. The formal education and training system provides this fundamental knowledge and skills, although some people have made it in the games sector without a formal education. The actual skills used in innovation are developed after graduation. A comment typical of all firm respondents about whether fresh graduates were useful for innovation was that ‘they are not very useful for at least two or three years, it takes that long to learn how to produce at a commercial level’.

Training in the games sector has evolved over a decade, from undersupply ten years ago, to an oversupply now. In the 1990s many experienced people came from overseas, and companies still source some experts through immigration. Although there are many games-specific courses at the vocational education and university levels now, a large proportion of these are simply rebadged programming or arts courses with a couple of games units added. The games sector’s primary fields of expertise are artists (34.3%), programmers (29.1%), management (14.8%), designers (9.5%), quality assurance (7.3%) and other technical staff (5%) (ABS 2008). Formal courses are primarily divided between art and programming, with design an emerging specialisation. Entry-level education is moving from the VET level towards the university level. Degree qualifications signal dedication and intelligence, and the extra year’s education provides the research skills and greater theoretical knowledge that managers consistently claimed were vital to learning and creativity in the games sector, especially programming.

The education and training system that encompasses VET and university has thus created a set of pooled labour markets for people having skills in the various professions and, within these, in various tools and types of games. This is important in allowing firms to grow and shrink as projects move from initiation, through major production, to the end. The current major slump in the sector is causing an increase in the availability of experienced people and a decrease in the ability of firms to hire. On the other hand, the dedicated games courses are very close to the industry, which means

that their graduates have skills in using the relevant current tools and technologies, and thus can get jobs readily.

Every respondent said that to succeed in the games industry a person had to have passion. Passion drives research, learning and experimentation, interaction on social networking forums and reading and investigation outside work. The passionate and talented individuals are those who drive the innovation that makes games companies competitive.

There is an active relationship between the games companies and the education and training system. Most teachers have worked in industry and often still undertake part-time games work. The teachers have strong interpersonal networks in the sector and become aware of the latest developments rapidly. Furthermore, most courses conduct both formal and informal benchmarking and industry surveys. A great deal of knowledge exchange occurs through conferences and online social networking sites. Many professionals and academics produce articles on innovations, and these are read by teachers. The constant change in technology, tools and techniques means that training organisations have to be actively engaged with industry to ensure that training provides students with the skills and knowledge they need for work. Although the industry bodies are actively attempting to influence the skills development agenda, they are weak in terms of resources and have so far had no major effect.

Conclusion

Our overall conclusion is that, from the point of view of innovation, the education and training system (especially VET) should focus on providing people with the core skills for their particular vocation and the ability to learn and adapt. Through this educational foundation, two worthwhile outcomes are achieved: firstly, innovation is supported, therefore advancing the nation's economic development; and, secondly, students are provided with greater employability over time, and thus better wages and career paths. At the VET level a focus on teaching current on-the-job competences and knowledge often leaves students underprepared for the changes in the workplace deriving from innovation. Thus we strongly argue that it is the ability to learn in each vocation and profession that is vital.

How the VET system affects the abilities of individuals and firms in generating, dealing with, and diffusing innovations

How the VET system affects the abilities of individuals and firms in generating, dealing with, and diffusing innovations was found to differ by sector. It is clear, however, that the role of the VET system and of the formal education and training system in general, is to provide individuals with the capability to be innovative and with the capacity to learn. More technically skilled people with a better grasp of the fundamentals of their vocation were better able to generate, deal with and support innovations. Our research did not identify any generic innovation skills, with the 'innovation' skills used differing by sector and firm. In two sectors the VET and university levels are becoming blurred—computer games (strongly) and solar energy (weakly). In the mining sector however they remain quite separate. This issue is becoming increasingly important (Wheelahan et al. 2009), and this research shows that in some instances the co-evolution of skills and innovation naturally leads to the VET and higher education systems merging.

Each sector we studied had quite different commercial dynamics and patterns of innovation that drove the skills profile sought in employees, how the firms organised work and innovation, and how they upgraded worker skills. A key message is that firms innovate; not individuals. This means that a focus on the innovation abilities of individuals by education and training researchers, practitioners and policy people may miss the actual skills development needs of employers. What firms need are people with skills that accord with the firm's organisation, structures and activities.

Mining firms use a Tayloristic work organisation, whereby professional engineers and trainers structure and tightly specify operator learning for innovation. Skills development therefore is aimed at the very specific competences required for jobs, with learning achieved through formal VET and on-the-job training. Solar energy firms had small autonomous teams and required electricians and CEC-accredited workers, which means that skills development occurs through formal courses for licensing and accreditation and informal learning in how the firm does its work, based on electrotechnology fundamentals. The games firms created specialist teams, with designers having overall control of each project, and relied on creative, passionate experts to develop innovations. Skills development in this sector is reliant on the fundamental knowledge and skills (usually) gained through VET or university courses, and the individual's ability to learn new tricks and tools. In all sectors ongoing innovation made current skills less valuable than an ability to learn and adapt. Even in mining, trainers recognised 'theory' for dump truck drivers as important in enabling them to adapt to new equipment.

Labour markets are a vital means by which firms gain skills and change their skills mix to suit their innovation. The VET system, through training packages, provides a common language and skills set. Mining is characterised by nationally recognised tickets and licenses corresponding to competences in the training package. This leads to pooled labour markets, where firms know that, within limits, there are a number of potential employees with the necessary competences available to them. Solar energy firms require people with particular qualifications and accreditation, and so are very tightly bound to the licensed electrician system. Computer games firms require people across a range of professions, and games firms, once people are employed, tend to develop key people internally. In the mining and computer games sectors immigration was important.

In the mining and solar sectors regulations and legislation were vitally important in the relationship between skills and innovation. In the mining sector regulations link to specific competence requirements for operators, but not to qualifications, except at the supervisory level. In solar energy there is a strong linkage between regulatory requirements for qualifications and accreditation, the education and training system and how firms innovated. In games there was little regulation of any relevance.

How workers learn for innovation

Typically, the actual knowledge and skills workers use in developing and performing innovations are learnt on the job, through specialised training or through experience. But this informal learning is usually based on fundamental knowledge and skills gained through formal courses. Hence, a focus in formal training on the current on-the-job competencies of workers may actually inhibit innovation. This strongly supports the call from the recent review of the VET system by the Joint Steering Committee of the National Quality Council and the Council of Australian Governments' Skills and Workforce Development Subgroup for the 'need to revise the current definition of "competency" to embody the ability to transfer and apply skills and knowledge to new situations and environments' (National Quality Council 2009).

In general, the formal education and training system had little influence on learning related to specific innovations, but was vital in providing the underpinning understanding on which new learning is based. Although mining companies provide formal training on novel equipment, most learning about new equipment or methods of operations occurred on the job in informal ways, based on 'theory' learnt in formal courses. In solar energy the formal education and training that people received provided them with the ability to learn how to use PV installation technology and how to adapt to new equipment and design and installation methods. In games formal education provides an understanding of and experience with various tools and ways of working, and also the ability to learn new tools and ways of working, and to be creative. Thus, in all three sectors it is the informal skills development system, broadly considered to include specialised training, mentoring,

conferences, social networking, and individuals' learning through experience and experimentation, that produces the actual skills used in innovation.

Policy attention is usually focused on the formal education and training system, especially qualifications. Issues such as on-the-job training, co-workers' ability to mentor, and access to specialised expert training are important to individual development and industrial competitiveness, but currently have little policy attention. Education and training policy, including that relating to VET, typically uses qualifications as a key measure of the training effort and performance of the education and training system. In the mining (especially) and computer games sectors, firms care about specific skills and competencies more than qualifications. In the solar energy sector it is the regulatory requirement to have qualified and accredited workers to do the work that drives formal qualifications. Thus, from the perspective of innovation, and how firms compete, formal qualifications indicate only one aspect of the training effort individuals and firms undertake.

How VET keeps up with innovation

VET teachers keep up to date with innovations in technology and its methods using a wide range of linkages to industry. Each sector displayed quite different dynamics. The personal networks of teachers were important in all sectors, although they were established and maintained differently in each sector. In mining, linkages for trainers were structured by firms through formal structures and contractual relationships, while in solar energy teachers' networks are based around their working in industry, relationships with suppliers and informal relationships. In the computer games sector teachers' networks revolve around people they had worked with in industry, friendship groups, and online social networking. Other commonly used means of keeping up to date included suppliers, publications, conferences and other web-based media, with differences by sector. There were few industry or government bodies involved in assisting teachers to maintain currency with innovations; academic research was of little significance in the sectors studied.

In each sector the strength, attitude, and linkages of the various actors that connect firms to the education and training sector were vital. Industry bodies, whether general or specialised in skills, or resourced publically or privately, filled this role and shaped the array of skills available to the industry. These industry bodies tended to reinforce a path of sectoral development, requiring a certain set of skills. Alternatively, individual people and organisations interact with teachers and provide rapid and precise feedback to one another. This individual interaction allows freedom in skills development, especially the acquisition of new necessary skills and innovations.

Future directions

To improve on the current strong, positive features of the training packages, our research indicates that explicit attention to fundamental knowledge is important. Learning fundamental knowledge increases the capacity of individuals to solve problems and adapt to new situations and technologies.

The current cohesive, single structure of qualifications, ranging through VET to the university system, facilitates knowledge and skills upgrading. In computer games there has been a shift from VET towards degree-level education, while in mining and solar energy VET remains the focal level of education and training. The innovation literature shows that some industries may move from a higher level of education to a lower level as work becomes routinised. The current situation of overlapping VET providers and universities is thus potentially valuable.

The ability of VET teachers to keep up to date varied greatly in our studies. In some large companies (especially mining) and in many private providers the resources and flexibility for teachers to keep up to date are available. However, in TAFE and in some private providers there are resource limitations and red tape (for example, public liability and workers' compensation issues) that limit the ability to keep abreast of innovation in technology and industry practice. An

additional stream of funding explicitly to provide up-to-date materials and intelligence on industry and technology would greatly assist in keeping the VET system current. This task could be performed by a central agency/ies, such as the industry skills councils, or, alternatively, state-based agencies could assist VET in keeping current.

Closer policy links between innovation and skills development would be valuable and would reflect the close relationship between innovation in industry and skills development, as shown in our research. Better policy links can assist Australians to have the right skills to be fruitfully employed and Australian firms to compete and grow.

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Some thoughts on VET and innovation: an economic perspective

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At the end of the one-day forum on innovation held in Sydney in November 2010 Tom Karmel gave a short concluding address. This chapter reflects his summary remarks.

The driving force behind the interest in innovation is that it feeds into productivity growth and hence economic growth and improved living standards, as pointed out by the Organisation for Economic Co-operation and Development (OECD 2010). Thus innovation is not an end in itself but an element of economic growth.

While a theme of this volume is how VET feeds into innovation I thought it would be useful to take a broader perspective on how education feeds into economic growth. This then provides a framework for thinking about the need for or desirability of government intervention in the education market and its role in promoting innovation.

A very simple model, and the one used by the ABS in its measurement of productivity growth, is to assume that the output of the economy is a function of capital, labour and technology (see ABS 2010). This implies that economic growth can be achieved through increases in the amount of capital in the economy or labour, and by changes (improvements) in technology. From such a simple model the ABS derives changes in technology (which they label the growth in multi-factor productivity) by taking economic growth and deducting the contributions explained by the change in the capital stock and changes in the quantity of labour.¹

We tend to think of the change in multi-factor productivity as being the result of technical progress, which typically is aided by innovation. But there is a difficulty here because multi-factor productivity is measured by a residual. This means that if we measure capital and labour in a more sophisticated way, we tend to get smaller residuals and therefore a lower level of growth in multi-factor productivity. For example, Karmel (1995, p.91) took into account the changes in education levels of the workforce and estimated that over the period 1968–69 to 1989–90 changes in the educational structure of the workforce accounted for around 30% of productivity growth (0.4 percentage points of annual economic growth compared with total multi-factor productivity growth of 1.4%). While these calculations are a little dated, they do make the point that multi-factor productivity is a residual and the better we measure the quality of labour and capital, the smaller is the role of multi-factor productivity. In addition, the fact that multi-factor productivity has

¹ As an aside, the ABS also derives labour productivity, but in my view it is not a particularly useful concept because labour productivity (basically output per unit of labour) is impacted by variables which have nothing to do with labour or how skilled it is. For example, an increase in capital will typically increase the productivity of labour.

detracted from economic growth for the last six years (up to 2009) suggests that innovation is a rather minor player in economic growth.

While the growth accounting framework described above is the one used by the ABS, it is a little old-fashioned in terms of economic thinking. Economists now think of economic growth as an endogenous process, building on the work of Romer (1990) and others. The growth accounting framework leads to decreasing returns from capital and labour; by contrast endogenous growth theory allows growth to continue ever upward. The general idea is that technological growth makes the generation of further technological growth easier, with many mechanisms posited. That is, learning makes learning in the future easier, or the generation of a blueprint today makes it easier to generate more blueprints tomorrow. Education has a central role in this process. For example, learning to learn makes it easier to acquire new skills as well as increasing current skills. Or increased education among parents will lead to increased education levels for children.

The point of the above analysis is to establish the relationship between education and training and economic growth in order to provide a framework for thinking about government involvement.

One obvious approach is to focus on initiatives which directly feed into innovation or labour productivity. An example is to focus on management education as a way of improving labour productivity. Agarwal and Green's chapter takes this approach by arguing that improved management education is an important element in innovation and therefore it is something that needs the attention of governments. They point in particular to a long tail of firms in Australia with poor management practices.

An alternative approach is to think about the government's role at a much higher level. I argued earlier that education has two roles in the economic growth process. The first is by increasing skill levels and therefore improving the quality of labour. The second is by stressing the 'learning to learn' role of education. From these two perspectives, there is a strong argument that governments need to focus on ensuring that their investment in education (and training) is well directed by avoiding investments where the returns are low and encouraging education that promotes 'learning to learn' rather than specific skills. This line of argument is challenging for the VET sector. Firstly, there are large numbers of students undertaking (government-subsidised) courses that at first sight have little pay-off in the labour market.² Perhaps this investment could be better directed. Secondly, the VET philosophy of training individuals in industry-required skills is not congruent with an argument that it is general education that promotes the 'learn to learn' skills that feed into technological growth.

This type of approach does not stress a direct role for government in innovation. Taking that approach a little further, I would argue that governments can play a critical indirect role by promoting institutions that in themselves promote an efficient allocation of resources across the economy and also promote the 'endogenous' aspect of economic growth. What I have in mind here are things like:

- ✧ the use of market competition as a way of driving innovation and getting rid of poorly performing firms (for example, those with poor management practices)
- ✧ an open economy to encourage the diffusion and adoption of ideas
- ✧ a strong finance system and capital markets that allow firms to innovate without being constrained by lack of capital.

Of course, governments are political animals and need to respond to the electorate. Inevitably, particular initiatives can be persuasive in the day-to-day political cauldron. My point is that

² Under the growth accounting framework the quality of labour is measured by the wages of workers, which are taken to reflect the marginal product of labour. In practice, this means segmenting the workforce by education level, with average wages in each segment reflecting skills differentials between segments.

governments should not lose sight of the big picture of how education impacts on the economy in the need to respond to calls for particular initiatives.

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