GROUP OF EIGHT

Role of universities in the national innovation system

Discussion paper

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Contents

Executive summary

Innovation is the deliberate introduction of change to add value and improve performance. It draws on the knowledge, skills, understanding, experience, curiosity and imagination of people as they display these within a particular context and apply them through the identification of opportunities and the solving of problems.

Over recent years governments have been placing more emphasis on innovation as a source of national competiveness. Governments now assess their investments across many areas in terms of the contribution that such investments make to increasing innovation. This has been especially significant for education and in particular for the development of policies for universities because universities perform research as well as provide learning. The measures governments use to assess the performance of universities frequently include indicators of research-related engagement with business, or of the level of patenting, licensing and start ups.

Assessing university performance by focusing on just some of the direct services or outputs that universities provide, or on narrow aspects of their individual services, seriously underestimates the contributions that universities make. This can lead to misleading perceptions of what innovation is, or of how innovation processes work. Using inappropriate measures of university performance has the potential to distort university operations and strategies, to the harm and impairment of national wellbeing.

One of the most important functions of universities is to provide a learning environment which releases the latent potentialities of their students and provides them with the abilities they need to promote innovation, in whatever sector of the economy they subsequently work. University research can help support this learning environment and produce outcomes which complement and support business research and innovation.

The strength and wellbeing of our universities is critical to national innovation and the overall effectiveness of our national innovation system. However, university commercialisation activities provide a poor measure of the importance of universities because they do not reflect the myriad of ways in which business makes use of university research.

Improving the performance and contribution of universities requires university leaders to think broadly and to innovate in response to society's changing demands and the increased complexity of the challenges that Australia does and will face. This will lead to diversification as different universities specialise, focus and respond to newly emerging challenges and opportunities, including those presented by the changing student population. However, they need to do this without moving back from their focus on excellence, on merit and on freedom of intellectual inquiry and public debate.

As part of an interconnected innovation system, universities and business are interdependent. They both make essential contributions to the wellbeing of Australia. In working more closely together they can benefit each other in a way that can only strengthen the nation's development. For such engagement to work, however, it is important that both sectors not only recognise but respect the contribution of the other. Acknowledging the importance of innovation, the breadth of the innovation concept and the multiple ways in which universities contribute to innovation as well as the breadth of their responsibilities is one way of promoting this mutual understanding and providing the basis for stronger cooperation.

Introduction

Over recent years governments around the world have been placing more emphasis on innovation as a source of national competiveness. One consequence of this has been that governments assess their investments across many areas in terms of the contribution that such investments make to increasing innovation. This approach has been especially significant for education.

Because innovation flows from the creativity, knowledge and competencies of people, providing a higher quality education for future workers is seen as an important strategy for invigorating the national economy. This requires an education system that is effective at all levels, from primary schools to postgraduate training; a system which supplies people having the academic, technical and trades skills the nation needs; and a system which covers all disciplines.

The demand for education to support higher levels of innovation has been especially apparent in the development of policies for universities. This is because universities perform research as well as provide learning. Research is often seen as the most important driver of innovation, especially of technological innovation. For this reason the measures governments use to assess the performance of universities frequently include indicators of research-related engagement with business, or of the level of patenting, licensing and start ups.

In Australia this link between universities and innovation has received a structural manifestation in the government's creation of a Department of Innovation, Industry, Science and Research (DIISR). This department combines (among other things) responsibilities for industry policy and programs with university research funding. DIISR shares the Commonwealth Government's responsibility for universities with the Department of Education, Employment and Workforce Training (DEEWR).

There is no doubt that universities play an essential and central role in any innovation system, or that their work and the services they provide are critical to maintaining a strong, flexible and resilient economy. However, there can be a danger that debates on how universities contribute to national development take too narrow a view by focusing on short term and direct measures of commercial value, ignoring the broader economic, social, cultural and environmental impacts and the effect of these on national reputation and credibility. For example, Australia's ability to play an influential role in international discussions on global problems in no small part reflects the contribution Australian universities have made to identifying and analysing options for dealing with these issues; and the foreign direct investment (FDI) decisions made by multinational enterprises take into account the strength of a country's public sector research system, including its universities.[1] Similarly, Richard Florida has argued that research universities play a critical role in the creative economy by helping to generate the 'progressive, open and tolerant people climate' necessary to attract innovative businesses and stimulate their development.[2] In fact there are many and diverse ways in which universities contribute to national wellbeing by supporting innovation, all of which are important and all of which the policy debate needs to recognise.

Assessing university performance by focusing on just some of the direct services or outputs that universities provide, or on narrow aspects of their individual services, will seriously underestimate the contributions that universities make. Moreover, such an approach can result in misleading perceptions of what innovation is or of how innovation processes work. To the extent that this leads to inappropriate measures of university performance it has the potential to distort university operations and strategies, to the harm and impairment of national wellbeing. For this reason, this paper starts by considering what we mean by innovation.

1. The major US report *Rising above the gathering storm* noted that among the criteria that multinational companies use in determining where to locate their facilities are the quality of research universities and the fraction of national research and development supported by government. www.nap.edu/catalog/11463.html

2. Richard Florida (2002). *The rise of the creative class*. Basic Books.

Innovation

Government development of innovation policy often takes place in the context of science, technology and research policy. While there are many reasons for this, not least being the sound market failure reasons for government support for research, this context can result in a narrow interpretation of what we mean by innovation. As emphasised by the recent OECD work on innovation (initiated by the OECD's March 2007 ministerial meeting request for an innovation strategy), innovation is necessary across all sectors and for all kinds of activity.[3] Innovation is as important to the public sector as it is to the private; and increasing the rate of innovation is critical if the world is to respond effectively and in a timely way to such global problems as climate change, food security and energy sustainability. A clear demonstration of the importance of innovation, its pervasiveness and the breadth of expertise that it draws on is that the development of the OECD strategy involved all OECD directorates.

There are many definitions of innovation. As one example, the Productivity Commission, in a major study of public support for science and innovation, used the following definition:

> *Deliberative processes by firms, governments and others that add value to the economy or society by generating or recognising potentially beneficial knowledge and using such knowledge to improve products, services, processes or organisational forms.*
>
> *Improvements may be new to the entity, the industry, the country or the world.*[4]

More simply, innovation is the deliberate introduction of change to improve performance. This can involve developing (or purchasing) and applying technology to create value. However it can also involve other sorts of change. For example, the OECD Oslo manual, which provides guidance on the measurement of innovation, includes new marketing methods, new organisational methods in business practices, new workplace organisation and new external relations as examples of innovation.[5]

Surveys of innovation in Australia (and in other countries) consistently find that despite the attention given to technological innovation, more companies invest in non-technological innovation than in technological innovation. In 2008-09, the proportion of Australian businesses that introduced new or significantly improved goods and services was 18.2 per cent. The equivalent figure for operational process innovation was 16.3 per cent; for organisational and management processes, 19.4 per cent; and for marketing methods, 17.2 per cent.[6] Moreover, technological innovation is as likely to involve the purchasing or licensing of technology, as it is to involve the research-driven development of new processes, products or equipment; and in most cases a firm will need to incorporate significant non-technological innovation to fully capture the benefits of any technological innovation. New equipment will require new business processes, staff training, often new markets, and so on, if the firm is to capture the benefits the technology is capable of providing.

In recognising the breadth of innovation as a concept, it is also useful to make the distinction between the more common incremental innovation, the lower-risk tweaking of existing systems and ideas in a process of often continuous improvement; and radical innovation, the much rarer generation and exploitation of new opportunities which is subject to high levels of both technical and market risk. This distinction is important because while most businesses will focus on the incremental approach, building on what they already know and exploiting the opportunities they have already identified,

3. *The OECD Innovation Strategy: getting a head start on tomorrow*. OECD. 2010.
4. www.pc.gov.au/projects/study/science/docs/finalreport
5. www.oecdbookshop.org/oecd/display.asp?CID=&LANG=EN&SF1=DI&ST1=5LGPBVQFQ4G5
6. www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8158.02008-09?OpenDocument

radical innovation will often depend on breakthroughs in understanding and technology that go beyond current expectations. The implications of such breakthroughs will often take a long time to become apparent and the route through which they lead to commercial activity or other economic outcomes is often convoluted and indirect – but this does not lessen their importance.

As a broad generalisation (with many exceptions), the developments that lead to radical innovation will come from universities and government research agencies operating on longer timeframes than business and independently of current market expectations and demands. Scientists at the end of the 19th and beginning of the 20th centuries who studied atomic structures and the nature of light did not have a long-term strategy to develop microchips, lasers, DVD players and new surgical instruments.[7] However, it would have been impossible to invent these things without the knowledge created by these early researchers. In a completely different area, abstruse research in number theory, conducted in its own right and without any potential application in mind, provided the foundation from which more applied mathematicians were able to develop the encryption technology which supports much of our financial system and enables us to use safely everything from credit cards to emails.

One further consequence of accepting a broader view of innovation is the need to acknowledge that while research is an important driver of innovation, this has to encompass research beyond the boundaries of the science, technology, engineering and maths (STEM) disciplines. Improved understanding and knowledge that derives from research in the humanities and social sciences can be critical in ensuring successful innovation and the public acceptance of new technologies. The cultural, legal and ethical issues associated with biotechnology or nanotechnology provide well known examples but there are many others, such as robotic engineers working with theatre directors to make robotic responses more acceptable (and less threatening) to people. However, the importance of non-STEM disciplines goes beyond their ability to smooth the path to impact for other technologies.

Research in the humanities, arts and social sciences is necessary to create the evidence base and foundation for the development of new approaches in policy development and implementation across many areas, ranging from the delivery of social services to environmental management and innovation itself. Similarly, the value that arises from developing content in the creative industries requires excellence in arts education, training and research – and it is the content that adds serious value and generates the markets, not the hardware. Innovation is about putting new ideas to use and innovation is as important in the social and cultural domains as it is in the government and business sectors.

Innovation draws on the potential of people

Universities provide learning opportunities designed to release the intellectual, cultural and social potential of their students. This makes them central to the innovation process, which depends totally on the capabilities of people and on productive interactions between people having different skill sets, knowledge and perspectives. Innovation is not something that industries do, or firms do or governments do. It is something that the people within those organisations do, not usually as individuals but as teams that nevertheless draw upon and depend upon the abilities of individual people. To make this clear, it is worth considering the process of innovation within an organisation.

Innovation is the process of introducing change to improve performance or add value. This requires someone to identify the need or opportunity for change and the nature of the change that is necessary. Within any organisation there are many people with ideas for change. They draw on their imagination, creativity, enthusiasm, expertise, knowledge, experience, networks, values, and objectives in the

7. Lasers were originally seen as a 'technology without a purpose' or 'a solution looking for a problem' and practical applications took years to develop.

context of the particular environment within which they are working. Different people are likely to have different views on what needs to change, the most appropriate direction for change or which of the various options available will provide the best, most effective or cheapest solution, or the greatest benefits.

If an organisation is to draw on this human potential effectively, there is a need for leadership – someone (or some group) to take charge, assess the various ideas, identify those which are most practical and, consistent with the organisation's vision and strategic outlook, make decisions to implement them. The qualities necessary to take on this leadership role are different from (but not incompatible with) those necessary to generate the ideas for change in the first place.

Depending on the scale of the proposed change and the extent of the intended innovation, the leader will need the support of people able to plan. This can be a complex process because while all innovation requires change within the innovating organisation, most innovations also require external stakeholders to change. The success of an innovation can depend on suppliers, customers, citizens and others changing their behaviours to accommodate the benefits of a new product, process, policy or program. In cases of large scale innovation, other stakeholders may also need to invest considerable sums that go beyond the purchase of a new product or process. (Think, for example, of introducing a large aircraft beyond the capabilities of existing airport infrastructure; or of the complementary infrastructure investment decisions needed to introduce electric cars.)

Plans must be flexible and able to respond to changing circumstances. However, they have value only if there are competent managers having the skills, knowledge and networks necessary to implement them. Looked at broadly, successful innovation is about successful management.

Managers are able to work effectively only if they have access to finance. While in most cases this will come from the operating budget of the organisation, in the case of large scale innovation there may be a need for external funding. The availability of external funding depends on a strong and effective financial services sector staffed by people having the appropriate skills and a wide enough perspective to recognise and mange risk in a way that does not stifle change. External funding is especially important in the case of start-up businesses, although even here the main source of funding is generally from the 'three fs' (family, friends and fools).[8]

With access to finance, managers need to acquire the technology (and people able to use it) necessary to implement the agreed plan. This requires a different set of skills and knowledge, including an ability to identify what technology is available and to assess what is most suitable for the job in hand.

Access to technology may in itself identify the need for improvements in the available technology, leading to ideas for additional technological innovation and the need for research to develop these improvements. (Innovation surveys consistently show that customers are one of the most important sources of new ideas for innovations. The other major source is suppliers. In contrast to customers who identify needs, the suppliers will often present new opportunities based on their own improvements and innovations.) Note, however, that if someone identifies the need for research, this takes us right back again to the start of this sequence, emphasising the iterative, interactive and people dependent processes that are necessary if innovation is to take place.

At the end of the process, there will usually be an evaluation and assessment leading to additional learning and new opportunities – including for innovation within the innovation process itself.

In many ways this account is simplistic. In reality there is no linear process. Innovation, even on a relatively small scale, involves many interactions and iterations with much debate, confusion and learning. There are many environmental factors (or 'framework conditions') such as the legal system, tax

8. http://startups.com/questions/3243/what-do-the-three-fs-stand-for-and-how-can-that-help-funding

structures, company and government policies, etc., that can impede or facilitate innovation. However, what this account does emphasise is that innovation always depends on people.

Each and every stage of the innovation process depends on the quality and talent of the people taking part. This means that the success of any attempt to innovate will depend to a considerable extent on the qualities of the people participating in the process: not just on their knowledge and expertise, but also on their ability to communicate, to interact and empathise with other players, their ability to persuade but also their ability to listen, learn and take nuanced decisions based on the evidence available at the time. In short, innovation requires people who are rational but who also make use of creative insights, are able to look ahead and who see problems as obstacles they can overcome, not as excuses for doing nothing.

Innovation requires excellent and highly competent people across all areas of the innovation process. Even the most exciting and apparently marketable new technology will not realise its potential if it does not receive the support of very talented people working at all stages of the innovation process and in all sectors. Technical excellence may be necessary (although in some cases it is clearly not); but it is never sufficient in itself to achieve market or commercial success.

The importance of universities is that they provide many of the thinking, critical, expert, problem-solving and imaginative people who contribute to the strength of our national innovation system by working across all sectors of the economy. The challenge for universities is that they are educating people now for jobs in the future. By 2020 some of the people currently in universities will be working in jobs of a type that does not currently exist and which we may find difficult even to imagine. Moreover, there is a global trend for people to move between jobs with increasing frequency, which puts an even greater premium on the effectiveness of higher education in producing people having broad generic skills as well as specific disciplinary knowledge.

Too narrow a focus on the research output of universities misses the point – and has the potential to distort the nature of university research so that it starts to focus on realising known opportunities to the exclusion of the strategically more important role of creating the new prospects that at this stage we cannot even start to imagine.

Innovation systems

Universities form one component of the national innovation system. The system concept is important because it reflects the fact that innovation, and especially any major innovation, will require parties from different organisations and sectors to work together. Even when a single organisation comes up with the idea and seeks to implement it within the organisation, the success of the change may depend on customer or supplier willingness to change. In any substantial attempt at innovation there will be other necessary interactions with people from within a wide range of different organisations, from those providing research or financial services, to regulators, lawyers, IP experts, marketing agencies and so on. As already discussed, this requires effective communication between the people working in these different organisations. Effective communication builds on trust, understanding and a respect for the value that other parties can add in what can be a complex process dependent on many specialised skills.

Using the intellectual construct of an innovation system provides a framework from which it is possible to identify and explore the significance of some important characteristics of how innovation takes place. In particular, it is apparent that an innovation system has the characteristics of the systems studied by complex systems science. Among other things this means that the system as a whole is greater than its parts; it exhibits emergent behaviour – that is, it has characteristics that it is not

possible to predict from an adding together of the properties of its component parts. Complex systems are dynamic, changing and evolving in sometimes unexpected ways; and they often display non-linear properties.[9]

Taken together, the known characteristics of complex systems mean that it is not possible to predict, construct or micromanage an innovation system. This is an important conclusion from a policy perspective. It means that the essential policy responses to making the system more effective have to include the creation of appropriate framework conditions and the removal of impediments or barriers to the effective operation of the system. Among other things this requires promoting linkages between the different parts of the system; it also requires setting conditions that facilitate the specialisation and differentiation of institutions within the system. This allows the system to evolve as its individual components change in response to the opportunities, challenges and competition that will inevitably exist between (at first) similar institutions. Competition can force universities to experiment, to start doing things in a different way or to do new things – in other words, to innovate.

Innovation policies need to promote and facilitate diversity, not impose consistency; and they need to operate with devolved decision making rather than a central control, so that the processes of natural selection, as determined by market and other forces, can operate freely.[10]

Almost by definition, all parts of a system are equally important and this means that the effective operation of the system requires all parts to be functional. Putting additional resources into one part of the system will have no effect if that part of the system is not the limiting one. Moreover, the emergent properties of the system are a result of the synergies that arise from interactions between the different elements of the system, each of which has its own, complementary, roles and responsibilities. Similarity cannot generate creative value through interaction, as similar organisations working together increases scale without generating the creative tensions that lead to genuine synergies.

Having a system made up of specialised but interacting elements facilitates the creation within each element of a critical mass of skills and expertise; the development of a coherent culture within each element, appropriate for the principal objectives of that element; and the tailoring of procedures, management processes and governance arrangements according to the purpose and objectives of each element.

Different roles of universities and business within the research sub-system

As an example of the specialisation and differentiation that exists within Australia's innovation system, it is worth examining the research sub-system. The business, higher education, non-profit and government sectors each perform research. However, they operate in very different ways and seek different ends. This specialisation enables them each to develop and use governance arrangements and research management techniques appropriate to the outcomes they are seeking to achieve.

One important point is that business sector expenditure on research and development is much greater than that of the higher education sector. [11] In 2008-09 for example, the Australian business sector

9. J D Bernal's (1967: *The Origin of Life*) definition of life provides an excellent description of complex systems: life is a partial, continuous, progressive, multiform and conditionally interactive, self-realisation of the potentialities of atomic electron states.

10. While this has to be true of the system as a whole, it is important to recognise that with individual institutions there may be a need for strong central control and strong leadership to achieve the intended outcomes.

11. This is true globally and according to the OECD close to half of the world's R&D expenditure is accounted for by only700 firms. See www.oecd.org/innovation/strategy

spent $16.9 billion on research and development, the higher education sector $6.7 billion.[12] Despite this significant difference, the higher education centre devoted more 'person years of effort' (pye) to research and development than did the business sector (61 310 pye for universities compared to 53 556 pye for business). There were also differences in the composition of the research workforces of the two sectors. For example, 87 per cent of the higher education research workforce were researchers (including academics and postgraduate students), compared to 50.3 per cent for the business sector. In contrast, 32.8 per cent of human resources devoted to R&D in the business sector were technicians with 16.9 per cent classified as other staff, while in universities these two categories together make up only 13 per cent of the total effort.

It is even more instructive to look at the socio-economic objectives of the research conducted in each sector. Not surprisingly, 94.4 per cent of business research and development aims at economic development. The equivalent figure for the higher education sector is 23.8 per cent. The higher education sector directs the remainder of its research to society (49.7 per cent), the environment (7.8 per cent) and expanding knowledge (17.9 per cent). Similarly, the socio-economic objectives of commonwealth research reflect the responsibilities of the Commonwealth Government – 33.6 per cent goes to economic development, 21.6 per cent to defence, 21.8 per cent to the environment, and 13.9 per cent to society.

Another way to compare the roles of the different sectors is to consider the time frame of the research they perform. Pure basic research aims to acquire new knowledge for its own sake, so that any practical or economic outcomes are likely to be very long term, although this does not stop serendipitous discoveries of immediate practical significance.[13] Such research makes up only 0.5 per cent of business research and development and in total the business sector is responsible for 4 per cent of Australia's pure basic research. In contrast, 28.9 per cent of higher education research falls within the pure basic research category and the higher education sector accounts for 86.4 per cent of the nation's pure basic research effort.

At the other end of the spectrum, experimental development aims to produce, improve or install new materials, products, devices, policies, behaviours, processes, systems or outlooks. Work of this kind plans for clearly defined outcomes and often operates within a set, and relatively short, time frame set by market and other strategic constraints. Over 60 per cent of business research and development expenditure is spent on experimental development and the business sector accounts for 89.1 per cent of the nation's experimental development effort. By way of contrast, the higher education sector's contribution to Australia's experimental development is 5 per cent.

These differences between sectors, reflecting their complementary roles and responsibilities, are what one would expect within a well functioning system. For this same reason there are very big differences in the fields of research that the various sectors focus on, which again reflect the outputs and outcomes they are trying to achieve. Business sometimes claims these differences demonstrate a lack of responsiveness among the other sectors as to what industry needs but they rather reflect that the different sectors complement each other – they do not duplicate the effort of other sectors. The differences are also a reminder that the needs of government and society are broader than those of business and require a different balance of research.

As is apparent from the varying proportion of research effort directed to economic development, innovation is important across all areas of activity. Government needs research to stimulate

12. The data in this section are taken or calculated from the ABS *2008-09 Research and Development all sector summary* at: www.abs.gov.au/AUSSTATS/abs@.nsf/productsbyCatalogue/07E66F957A46864BCA25695400028C64?OpenDocument

13. Recognising that in the longer term almost any significant advance in knowledge will have practical significance, some commentators refer to basic research as 'research not yet applied'.

innovation and improve the effectiveness of its defence, environmental management or health care responsibilities, for example. The outcomes of such research contribute to national wellbeing in many ways, including but going beyond, greater wealth, improved productivity and the potential for reducing taxes. Innovation in the provision of government services or in the performance of government-provided infrastructure can have major direct and indirect impacts on business competitiveness and productivity.[14] Similarly, academic research can have many broad, intended and unintended, benefits for business. For example, university research can provide information which facilitates the development of free trade agreements or which leads to the removal of technical barriers to trade and so create new market opportunities for whole sectors, not just individual firms.

In any case, while the pure basic research performed in universities may not meet the immediate needs of business, in the longer term it is this research that will create new business opportunities and develop consumer needs and markets that do not yet exist. It is important not to underestimate the economic potential that basic research can unleash. As Margaret Thatcher noted:

> *"Although basic science can have colossal economic rewards, they are totally unpredictable. And therefore the rewards cannot be judged by immediate results. Nevertheless, the value of Michael Faraday's work today must be higher than the capitalisation of all shares on the stock exchange."*[15]

Applied research and experimental development are often building on the knowledge and opportunities created by basic research. As a trite example, one has only to think about the basic research that led to the development of electronics, computers and television or of visual display units more generally and which made possible mobile phones, the internet and all the services that depend on them. In deciding to study the deflection of cathode rays subject to simultaneous magnetic and electric fields, J J Thomson was not working to establish an electronics industry but his discovery of the electron, when combined with earlier work by people such as Faraday and Maxwell, was an essential step to the technological world in which we live today.[16] It is not possible to pursue long term economic growth without testing ideas, advancing knowledge and improving our understanding of how the world operates.

There is another, important difference connected with the research performed by the different sectors. By definition, experimental development strives to achieve a single, explicit output having the particular characteristics necessary to achieve an agreed outcome. In general this outcome has been set by the business and technology development strategies of the firm or other organisation conducting the research. The output parameters are set in advance, reflecting in part the capabilities of the firm (or firms) conducting the research; and any benefits that result from the research which are additional to the intended output are, in a sense, irrelevant to the firm.[17] In any case, the firm performing this research will normally use whatever options it has available, including the use of trade secrets and formal IP protection, to retain the benefits of research within the firm.

The situation with most university research is very different.[18] This is because most research performed by universities is multipurpose. One indication of this is that the definition of university researchers

14. In this context it is relevant that 16.9 per cent of Australian businesses employing 19 to 199 persons identify government regulations or compliance as a barrier to innovation. See: www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8167.0Main%20Features92008-09?opendocument&tabname=Summary&prodno=8167.0&issue=2008-09&num=&view=

15. Taken from: George Will, "A fire that needs stoking", *The Australian Financial Review*, 20 January 2011, p.46.

16. Faraday's disinterest in the immediate practical application of his research is shown by his purported response to William Gladstone, then British Chancellor of the Exchequer (minister of finance), who asked Faraday in 1850 about the practical value of electricity. Faraday's only response was: 'One day sir, you may tax it'. On another occasion, in answer to a question about the use of his studies on electromagnetism, he supposedly responded with Benjamin Franklin's comment: 'What use is a new born baby?'.

17. Although the presence of such spillovers or positive externalities provides an important rationale for government support of such research.

18. One exception here is when a university conducts contract research fully-funded by a business.

includes postgraduate students. An explicit and intended purpose of university research is to train new researchers. Moreover, the purpose of university research is not to add directly to the bottom line of the university but to advance knowledge and provide useful information that will flow beyond the boundaries of the university.

Even when university research has an output of potential commercial value, it will not usually be the university itself that is responsible for taking it to market. The context of university research will often mean that its research has generic value that goes beyond the needs of an individual firm. Because university research does not usually aim to produce an output having particular technical specifications reflecting the needs and capabilities of a specific user, it is generally more open-ended. This means that it is often useful to, or significant for, a wide range of users – not least other researchers in other universities. The outputs of university research are widely disseminated using formal and informal mechanisms and the research process, outputs and outcomes inform teaching, together providing an important part of the learning environment that benefits all students – not just postgraduates. Business receives the benefits of this when it employs graduates from whatever field.

The reality of innovation systems

An innovation system is an intellectual construct, a concept that is useful in drawing out the need for complex interactions between multiple players in order to create constructive and useful change. The innovation system is also a social construct, both in the sense that the concept has arisen from the intellectual activity of people but also, and perhaps more importantly, in the sense that the system results from productive interactions between people working within the different components of the system. In effect this means that the system has no concrete existence – there is no set pathway through a defined group of institutions to achieve effective innovation. Instead, there are many individual systems and each innovation depends on its own unique set of interactions between a diversity of players. This is why framework conditions that facilitate rather than impede interactions and cooperation are so important. This is also why the ingredients for significant innovation in different sectors can be so diverse.

To take one example, technological advances across many different fields can lead to innovation within the defence sector. Advances in everything from laser technology to genetic engineering, materials science and propulsion systems provide explicit opportunities for improving the performance of national defence forces. Within Australia complex linkages between bodies such as DSTO, CSIRO, universities, the defence industry and the defence department, as well as other government agencies, international organisations and similar bodies in other countries, form part of the defence innovation system. However, the changing nature of warfare and the issues currently impacting most on national security mean that a focus on technological innovation is not sufficient. The development of language skills and linguistics, the study of different cultures, an understanding of the factors that impact on people's beliefs, attitudes and behaviours, and a deep knowledge of ethological, political and theological issues in different countries and cultures can be equally, if not more important. Understanding the causes of conflict and how to address them is central to 'capturing hearts and minds' and critical to the gathering and analysis of high quality intelligence.

The networks of institutions, disciplines and policies that interact to form the defence innovation system may overlap with but will be different from those that contribute to the construction sector innovation system or the education system innovation system. Each of these has some unique and some shared characteristics and institutions. Innovation in defence requires a broad integration of many different disciplines and a readiness to change priorities and approaches in response to the improved understanding that results, but this is not unique. Addressing issues such as feeding a growing world

population with shifting tastes, ensuring energy security or improving health outcomes all require a trans-disciplinary approach that draws upon institutions and people from all areas of society, domestic and international. A system which does not embrace all these components will be defective and lead to perverse outcomes.

Similarly, the innovation systems that we need to address climate change or which operate within the services sector, the manufacturing sector or within the public sector are each different from each other. Moreover, these systems are themselves made up of subsystems. Within the services sector, for example, the systems that promote and facilitate change and increased effectiveness are quite different within the education (or university) sector from those operating within the wholesale or retailing sectors – although all are important if Australia is to develop and improve the wellbeing of all its citizens.

The descriptions provided here of different innovation systems are both simple and simplistic, not providing any sense of the range of players, their different and often competing objectives or requirements and or of the complexity of the processes that link them. Attachment 1 provides a more detailed but still broad and outline description of some of the major players in the health services innovation system.

One consequence of this diversity and the multiform, multifaceted nature of innovation systems is that this places significant and broad demands on the national education system, including universities, in terms of the outcomes they achieve and the diversity of expertise and knowledge that they develop.

The role of universities

Universities support the innovation system by providing a continuing supply of learned people familiar with the most recent developments in their fields who then move out to other sectors to apply their knowledge, understanding and technical skills; through the research they perform which has many direct and indirect benefits; and through their outreach and broader community engagement activities which, among other things, can help maintain an awareness of emerging possibilities. However, they do much more than this.

The legislative basis for the Commonwealth Government's funding of higher education is set out in the *Higher Education Support Act 2003*. The objectives of this act are:

a. to support a higher education system that:
    i. is characterised by quality, diversity and equity of access; and
    ii. contributes to the development of cultural and intellectual life in Australia; and
    iii. is appropriate to meet Australia's social and economic needs for a highly educated and skilled population; and
b. to support the distinctive purposes of universities, which are:
    i. the education of persons, enabling them to take a leadership role in the intellectual, cultural, economic and social development of their communities; and
    ii. the creation and advancement of knowledge; and
    iii. the application of knowledge and discoveries to the betterment of communities in Australia and internationally;
c. to strengthen Australia's knowledge base, and enhance the contribution of Australia's research capabilities to national economic development, international competitiveness and the attainment of social goals; and
d. to support students undertaking higher education.

Universities have an explicit role in the cultural development of Australia and culture provides one of the important framework conditions within which the innovation system operates. A diverse, open society is not only more creative, it is also more tolerant of difference and more open to the take-up of new ideas and technologies than a more closed society. Indeed, a major factor impacting on innovation success is the preparedness of consumers to take up new things, to take risks and to try ideas. In many cases the exploitation and impact of new technologies depends more on the creativity of consumers than of those who develop the technology.[19] Consumers see opportunities beyond those that the inventor or initial innovator was able to envisage. Indeed, some analysts argue that consumer attitudes are more important in capturing the benefits of innovation than an ability to develop new technologies.[20] In providing an exciting and challenging learning environment, universities facilitate an open mind and managed risk taking approach among their students.

In providing training and conducting research in areas such as astronomy, archaeology and anthropology, or in history, politics, philosophy and the fine arts, universities are not only adding to knowledge, they are also helping to cultivate a sophisticated society that understands its own roots

19. An interesting recent example was the way in which hackers and others had developed a whole suite of innovative practical and artistic uses of Microsoft's Kinect gaming system within days of its release. See www.newscientist.com/article/mg20827894.600-inside-the-race-to-hack-the-kinect.html

20. See Amar Bhidé's papers, e.g. *Venturesome Consumption, Innovation and Globalization* at www.bhide.net/bhide_venturesome_consumption.pdf

and place in the wider world.[21] Such a society develops a self awareness, understanding and confidence that will support an environment within which it becomes not just acceptable but normal to debate, to recognise the value of differing perspectives and to embrace change. This is the kind of society that fosters innovation and attracts excellent people from elsewhere.

Teaching and research in these and other disciplines can also help create a stronger national identity and develop an international profile for Australia based on its contribution to scholarship and willingness to support world understanding. Cities with strong and vibrant cultural activities supported by the people who appreciate them attract even more creative people and promote innovation. Universities contribute in many and varied ways to the development of such cities. Indeed, a deficiency of the Higher Education Support Act's listing of the roles of universities is that it does not acknowledge the importance of universities in defining Australia's national reputation and providing national contact points for the global academic and research communities.

Learning and scholarship are important in their own right, quite apart from any direct economic or other impacts they might have. Investment in these areas reflects a cultivated society, a society open to self examination and questioning, and a society prepared to look beyond the immediate. University education provides an important means of self discovery, development and fulfilment, independent of any benefits that it might produce for wider society. However, even when the focus is on the economic return of universities, it is necessary to recognise the diverse ways in which society can receive an economic return, quite apart from any serendipitous benefits that might result from undirected research.

The creation of capability by developing expert and skilled people needs no further emphasis, although it is worth noting that this occurs at two levels – one being through disciplinary specialisation and providing people with specific expertise, the other through the development of more general attributes such as problem solving. Generating new knowledge goes beyond formal research and can encompass other forms of scholarship and the application of different perspectives.

Again, there are many ways in which universities disseminate knowledge to participants in other parts of the innovation system. One is through the training they provide to their students but other formal and informal mechanisms are just as important. Preparing text books and critical reviews, publishing in the formal and other literature, acting as public intellectuals by providing press commentary, radio or TV interviews, speaking at conferences, attending trade fairs and many other mechanisms all add to knowledge diffusion. Given the complexity of the innovation system and the importance of informal linkages within the system, it is important not to discount these considerable contributions to innovation while continuing to recognise the importance of consultancy, secondments, licensing, spin-offs and the other mechanisms that usually form the focus of innovation studies.

Innovation is not just about new products, processes and organisational changes but also about the application of new ways of thinking. As one example, research has led to the general understanding that the operation of natural processes can have a huge economic impact, whether through water purification, pollination of crop plants, or maintaining fish stocks by providing nursery conditions. This thinking has had major, even if unquantifiable, impacts on environmental policy and decision making. It is not possible to patent the concept of ecosystem services or even to trace the pathways through which it reached the consciousness of decision makers. However, there is no doubt that the underlying basis of this concept has permeated environmental and resource management decision-making to produce immense benefits – both direct and indirect – through better decisions and more informed policy and program development.

21. They also go beyond this. For example, the University of Copenhagen has noted that private business has recognised the usefulness of anthropological perspectives on product and market development and intercultural communication, as well as management and organisational development. http://antropologi.ku.dk

Sometimes forgotten is that knowledge and understanding do not always lose their relevance because they are old. Indeed, some information may have value precisely because it is old. Using the results of current research to inform policy can be risky because subsequent work might well demonstrate the conclusions of the research to be wrong. Universities play a sometimes unique role in storing and maintaining knowledge that other parties can draw upon as it becomes necessary. This is not a trivial activity, even with the current capacity for the almost unlimited electronic storage of data and information. This is because universities go beyond the simple storage of information to act as custodians of knowledge. They also maintain and assess its utility, significance and relationship with more recent knowledge, analysis and interpretations.

Importance of internal diversity within universities

In many ways one of the most important roles played by universities is that together they provide and maintain a broad base of capability. This provides a kind of national insurance, in a number of ways. By performing research and providing teaching across many areas, they serve to monitor developments across all areas of science, technology and other disciplines. Other players in the innovation system, including business, tend to focus their efforts more in particular disciplines or outcome areas, sometimes very narrowly defined. This can mean they miss developments in related or adjacent areas that can potentially impact in unexpected ways on their own operations.

Unlike a business or government research agency, the research within a university does not usually depend on enterprise level decisions and strategies. Rather, a university develops and maintains diversity because its research and areas of scholarship flow from the decisions and actions of many individuals. These are operating from the position of their own interests, curiosity and networks as coloured by the decisions of grant giving bodies and other funding agencies. The resulting multiplicity of capabilities, breadth of knowledge and strength of networks together form a critical national capability that governments or industry can draw upon as they need and as new and unexpected opportunities or problems emerge. Moreover, this breadth of research can be essential in identifying problems that need a response but which might not otherwise become apparent – whether these relate to climate change or major trends in social structures and organisation.

Universities are able to maintain this diversity because, while they are accountable to government for some of their funding, at an operational level they are autonomous. One important aspect of this autonomy is that they develop their own curricula and they award degrees. This facilitates the development and maintenance of diversity and the development of multi and interdisciplinary approaches to both course development and teaching. Equally important is that universities maintain freedom of expression. They uphold academic freedom and they encourage debate and the informed challenging of the status quo in a context in which such debate has high standards that require the debaters to address the evidence and the arguments supporting different positions and perspectives.

In many ways the greater the diversity of informed opinion within a university, the stronger it is. This is because this diversity makes the learning experience it provides for its students more effective. A research university adds value not by transmitting knowledge but by developing the capabilities necessary to challenge it. One consequence of this is that universities need to be sufficiently large to employ academics that span a range of different perspectives within each discipline. It is not enough, for example, to have a single economist. A sound education in economics depends on exposure to the different schools of economics, along with related subjects such as political economy and economic history. Similar arguments apply to all other disciplines: a single person cannot embody a wide range of different perspectives, even though they may be able to describe them.

Scale is also important in attracting the most talented players in any discipline. In part this is because a larger size implies a greater absolute level of resources and the economies of scale that provide the opportunity to provide infrastructure equal to any in the world; but it is also because the reputation of a department or institution reflects the number of star performers it can attract. Excellence feeds on excellence and the ability to compete with equally talented people. A large department also provides the possibility of nurturing local talent as well as attracting the best from elsewhere. By definition, only a small proportion of those active in any field can be top performers and it takes time to develop a reputation as a leader within any discipline. Even a world leading department will include academics who are not top in their field – and needs to do so – not least, to provide them with an opportunity to develop leadership status. This may be one reason that global rankings of universities often favour large institutions by using institutional rather than per capita performance in their metrics. Larger institutions, because they will normally encompass a wider range of disciplines, are also more able to adopt the multidisciplinary approaches that are becoming increasingly necessary to deal with the complex problems that nations – and the world – need to address.

Universities and commercialisation activities

Universities make a broad-based contribution to innovation and to the resilience, strength and reputation of the national innovation system, the value of which is difficult to overestimate. At the same time, they undertake direct commercialisation activity. The measures governments and others use to assess this commercialisation activity tend to be rather narrow. For example, Australia's National Survey of Research Commercialisation gathers data on:

- Resourcing for commercialisation
- Intellectual property activity
- Licensing activity
- Research contracts and consultancies
- Skills development and transfer activity
  - Research commercialisation and entrepreneurship courses
  - Research post-graduates employed in start-ups[22]

This kind of commercialisation activity is important because in some circumstances it provides the most effective (or only) means through which society can capture the benefits of research performed within the university. When successful, this kind of commercialisation can have the added benefit of providing additional revenue to the university. However, it is important that the potential for increasing revenue or the collection of data by governments does not distort university behaviour. As the Productivity Commission noted in its report *Public Support for Science and Innovation*:

> *… the pursuit of commercialisation for financial gain by universities, while important in its own right, should not be to the detriment of maximising the broader returns from the productive use of university research.*[23]

Universities and other organisations receiving public funding for research need to be very clear as to whether their primary role is to maximise the national returns from the research they perform or to internalise the returns so that the benefits flow to the university. In practice they do both but often without any clear policy as to how or when they should choose one over the other. One consequence of this is that they themselves underestimate the contribution they make to national wellbeing.

22. www.innovation.gov.au/Innovation/ReportsandStudies/Documents/NSRCReport200507.pdf

23. Public sector support for science and innovation p. XVI

Another point to note is that universities do not usually commercialise technology themselves – they transfer it to another organisation to commercialise. In some cases this might be a spin-off company but this approach tends to be high risk compared to licensing technology to businesses that already have the capabilities necessary to use and commercialise the technology and which have existing distribution networks and other infrastructure that they can draw upon. Universities do not form complete innovation systems in themselves but feed into and draw upon institutions that have complementary capabilities, information and market links.

Business demands on universities

Innovation is a broad concept and important across all areas of activity and in all sectors. Despite this, policy discussions still often concentrate on innovation within business. This being the case, it is useful to examine what innovating businesses seek from universities. The Australian Bureau of Statistics report Innovation in Australian Business, 2008-09 provides some useful data in this regard.[24]

In 2008-09, almost 40 per cent of all Australian businesses were 'innovation active', having either introduced or implemented an innovation, having an innovation still under development or having abandoned an intended innovation. The proportion of innovation active businesses varied with firm size (from 32.8 per cent of businesses having four or fewer employees to 66.7 per cent of businesses having 200 or more persons). There were also differences between sectors, with 30.8 per cent of construction businesses being innovation active compared to 50.9 per cent of businesses in wholesale trade.

Discussions of innovation and the role of universities often centre on the source of ideas and information for innovation. Attachment 2 summarises the ABS data which, as with all such surveys, demonstrates that people within the business, customers and suppliers are the main source of ideas – although, as already mentioned, many of the people coming up with these ideas are drawing upon the outcomes of their university education in doing so. (Apart from anything else, this reveals that in practical terms market pull is more influential than technology push in most of the innovative activities of business.)

Overall, universities or other higher education institutions provided the direct source of ideas and information for 2.6 per cent of innovating businesses, although there was some variation between sectors – from 0 per cent for the financial and insurance services sector to 9.4 per cent for the health care and social assistance sector. However, innovating businesses may have indirectly used university research and expertise to a much higher degree than these figures suggest. One indication of this is that 27.8 per cent of innovating businesses drew upon websites, journals, research papers and publications in coming up with ideas for innovation; and 21.6 per cent used professional conferences, seminars, meetings and trade shows.

As already emphasised, the direct and quantifiable commercialisation activities of universities make up only a very small proportion of the impact that universities have on the innovation activities of business.[25]

Also of interest is that only 3 per cent of businesses identified the lack of access to knowledge or technology as a barrier to innovation, while 27.1 per cent of innovation active businesses identified the lack of skilled persons as a barrier. In this context, data on the source of labour for innovation show

24. www.abs.gov.au/AUSSTATS/abs@.nsf/ProductsbyCatalogue/06B08353E0EABA96CA25712A00161216?OpenDocument

25. As previously noted, the business sector spends considerably more on research than does the higher education sector. Business sector researchers are usually well aware of relevant university research because they read the literature in which academics publish, use textbooks and attend conferences relevant to their own work. However, university researchers may be much less aware of business research and may not be using sources such as the patent literature on a regular basis to monitor what business is doing.

that 3.8 per cent of firms having 0-4 employees employ new graduates compared to 12.9 per cent of firms with 200 or more employees; and that the figures for work contracted out to higher education or research institutions are 2.4 per cent and 7.8 per cent of businesses, respectively.

The 2006-07 ABS survey collected data on the skills innovation active firms used for innovative activities. As shown in Attachment 3, there was considerable variation depending on the size and sector of the firms.[26] The overall ranking for the skill sets innovating firms were seeking, with ranges, was as follows:

Information technology 35.4 per cent (Mining 22.7 to Information, media and telecommunications 61.3)

Marketing 33.7 per cent (Mining 18.7 to 50.1 Arts and recreational services)

Business management 31.1 per cent (Rental, hiring and real estate services 20.8 to Finance and investment services 42.5)

Financial 21.2 per cent (Retail trade 7.6 to Mining 31.7)

Trades 19.3 per cent (Health care and social assistance 2.1 to Construction 43.4)

Project management 10.5 per cent (Other services 2.1 to Information, media and telecommunications 21.5)

Engineering 9.9 per cent (Health care and social assistance 0.1 to Mining 31.7)

Scientific and research 8.0 per cent (Transport, postal and warehousing 0.1 to Health care and social assistance 32.6)

Transport, plant and machinery operation 7.8 per cent (Health care and social assistance 0 to Transport, postal and warehousing 44.7)

These data emphasise the variety of skills that businesses need to support innovation and that too narrow a focus on a particular sub-set (such as scientific and research skills) can miss the demand and where opportunities exist. It is also clear that universities contribute to the availability of people having many of the skill sets in high demand; and that business would not be able to innovate if universities did not maintain this quality supply. ABS data on shortages or deficiencies in skills needed to undertake innovation make this even more apparent. Again, while there is variation between sectors, the overall ranking is: Trades (14.1 per cent of innovation active businesses); Information technology (7.3); Business management (5.6); Financial (5.1); Market (4.6); Engineering (4.6); Project management (3.3); Transport, plant and machinery operations (2.9); and Scientific research (2.0).

An overall conclusion is that what business most needs from universities is a ready supply of competent, talented and creative people able to apply their skills and further develop their potential across the whole range of business activities. At least some of these people will maintain indirect links with the university through the literature and informal contacts, drawing on these associations and others to come up with ideas for innovation which they are able to develop and apply within the context of a particular firm's environment, needs and capabilities. Moreover, if individual firms are to move forward and respond to emerging opportunities, the skilled people that universities provide need to have knowledge and skills beyond those that firms currently need because this is how they gain and develop the capacity to change.

Universities have value to business because they are different from business and operate in disparate ways. Universities do not add value by performing research which business can perform for itself – they add value by doing what business cannot or will not do and then ensuring that business becomes

26. www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8158.02006-07?OpenDocument

aware of the potential opportunities the universities have created. But this means that business itself has responsibilities – to maintain links, both strategic and tactical with universities, to make use of the opportunities that universities offer and to keep universities informed of changing business demands and developments.

Perhaps even more important is the need for business to recognise its dependence on universities and to support the universities in fulfilling their many roles within the broader innovation system. The complementary nature of business and university activities and roles makes them interdependent in many ways. By working together they can promote innovation, while in competition they can weaken the national potential for productive change.

Diversity among universities

One of the important characteristics of any effective system is that it facilitates specialisation and differentiation among its component parts. Together these allow the different elements of the system to become more effective and so increase the efficiency of the system as a whole. Given the variety of demands that business and the other sectors of the innovation system place on universities, it would be surprising if different universities did not exhibit the same trend. Some might specialise on serving regional or local needs, others on a broader national purpose and a few may seek to form or become part of international networks and alliances; some might concentrate on transmitting and storing knowledge and meeting the immediate needs of business or other customers, others on creating the knowledge and understanding that develop new opportunities, and others on developing and transmitting skills. Some might focus on undergraduate education while others strive to develop postgraduate course work degrees or the professional upgrading that is becoming more important as part of lifetime learning, and others concentrate on postgraduate education by research. In line with their overall strategy, some universities might decide to reduce or expand the disciplines they cover or to alter the balance of face to face or online teaching in response to the varying needs of the student population. As this differentiation proceeds, it would also create the opportunity for useful collaboration between institutions which have specialised in different directions.

Focusing effort in this way does not imply any hierarchy of excellence or that one role is in some way more important than or superior to another. Indeed, excellence is a function of context and purpose, so that specialisation is one way of increasing excellence with respect to the outcomes the specialisation aims to achieve. And as repeatedly emphasised, all parts of a system are of equal importance – poor performance in any component will limit the ability of the other components to perform effectively. Adopting a systems approach means taking a holistic perspective and valuing the interdependencies that exist.

Increasing diversity recognises that as the sector grows it becomes possible to gain efficiencies through specialisation, accommodating to the variety of niches that universities can and should fill. Moreover, such differentiation is an almost inevitable consequence of competition; and competition is itself a driver of excellence, in academia as elsewhere.

Specialisation becomes even more important as the relative number of students increases and as the proportion of the working population gaining university education also increases. As this paper has argued, innovation arises through difference, not similarity. A system that provides similar and consistent learning experiences and environments for all students is unlikely to promote the differences that result in progress. Moreover, an increasing student load means a more diverse student population.

Individual students may prefer or need different types of learning experience, have different learning objectives and prefer different styles or kinds of teaching. Students at both under- and post- graduate

level now span an age range greater than ever before; many are part-time and have non-university commitments – including work and family responsibilities. This also means that students are bringing to the university a much greater range of experience, expertise and maturity than was formerly the case – and in many cases the students have had practical work experiences beyond those of the people teaching or mentoring them. Moreover, with an ageing population leading longer and hopefully healthier lives, the demand for post-retirement personal development courses is likely to increase as lifetime learning proceeds beyond the needs of work. As a group, universities need to offer the full range of learning experiences that students seek or which become necessary to allow all students to realise their full potential. A one size fits all approach cannot do this or meet the very varied requirements of business in terms of the skills and capabilities they are seeking.

The USA provides an interesting example of some of the diversity that can exist within a university system and the potential for differentiation. In 2007 the USA had around 4,300 education institutions offering undergraduate degrees. Of these, around 600 also offered masters degrees and perhaps 260 were 'research universities'. However, according to one estimate, only 125 universities contributed in 'meaningful ways' to the growth of knowledge; and the skewed distribution of research activity even within this group meant that a small number accounted for a very high proportion of the discoveries that flowed from university research within the USA.[27] For example, in 2001 the top 200 universities accounted for around 96 per cent of all higher education research expenditures; the top 100 institutions received 51 per cent of the total public funding for academic research and the top 20 about 20 per cent.[28]

The vast majority of universities in the USA have a focus on the transmission of knowledge and the non-research aspects of scholarship. This does not make them any less important than the research universities but enabled them to perform an important job well and often in a way that served the explicit needs of their local communities. Attachment 4 provides an outline of the 2005 Carnegie classification of institutes of higher education, which provides yet another perspective on the diversity of universities within the USA.

Some of the recent policy initiatives in Australia may well help facilitate similar differentiation within the Australian university system. These include ERA with its explicit focus on research excellence; the use of compacts and the potential they provide for each university to develop a unique and explicit vision and mission, reflecting the niche it has chosen to occupy; and the move to have funding follow students, which will create increased market competition and the need for universities to specialise to meet the whole range of student needs.

In his book The Great American University, Jonathon R Cole has observed that it becomes more difficult for universities to distinguish themselves from each other and so compete effectively, when they are subject to significant government regulation; and that the success of the great American research universities is because they have operated 'in a relatively free market as well as in a free marketplace of ideas.'[29] Given the benefits of a differentiated system, it will be important that other Australian initiatives, such as TEQSA, do not operate in a way that impedes specialisation or which impact on university autonomy such that it becomes more difficult for universities to respond to student demand and society's needs. At the same time, it is important to recognise that TEQSA's role in maintaining confidence by supporting quality will become even more necessary in a more highly differentiated system in which new entrants appear in response to emerging and changing market demands.

27. Jonathon R Cole, 2009. *The Great American University*. Public Affairs, p. 6.

28. Stephan Vincent-Lancrin, 2006. *What is changing in academic research?* European Journal of Education, 41. This paper also presents figures for the UK where nine universities representing 10 per cent of all institutions and 17 per cent of post-graduate enrolments received 47 per cent of public funding for research. The top four universities received 29 per cent of public funding.

29. Jonathon R Cole 2009. *The Great American University*. Public Affairs. P.190

The role of the Group of Eight universities

The Group of Eight universities are aware of the pressures on the whole university system to change and have already discussed what this means for their own innovation trajectory, given their current strengths and the demands placed on them. As a result of these internal discussions they have identified their role as that of research intensive universities building national innovative capability. They have identified five underlying principles that support this position and which are consistent with the arguments presented in this paper. Underlying each of these principles is a commitment to excellence based on providing a learning environment supported by the conduct of fundamental, disinterested research and the provision of world class facilities able to attract the most talented people from around the world.

1. Go8 universities are responsible for producing advanced human capital, knowledge and know-how that underpins Australia's innovativeness

The Go8 universities produce many of the graduates who take up leadership roles in Australia and overseas, as well as most of Australia's top quality university research, particularly the basic research that underpins, often in quite subtle ways, major innovation. The universities provide a wide range of general, professional and specialist courses at undergraduate and postgraduate levels and play a special role in the formation of research-trained graduates and the development of post-doctoral scholars.

2. Go8 universities play a leading role in helping to understand complex phenomena and solve complex problems

Addressing the wicked problems facing contemporary society requires large scale, cross disciplinary approaches and sophisticated modelling. The Go8 universities have the research capabilities across a broad range of disciplines and the considerable multidisciplinary experience necessary to support Australia's contribution to these problems.

3. Go8 universities open and forge significant international knowledge networks for Australia

The Go8 universities play a special role in linking Australia to the world's knowledge production system because of their international reputation and the links they have established with some of the best researchers and research groups overseas. Their participation in these networks helps raise the standing of the whole national innovation system and provides a sound foundation for Australian participation in international actions directed at global problems.

4. Go8 universities contribute highly trained people, expertise and instrumentation which helps build and develop Australia's capacity for high quality education and innovation capacity

Go8 universities supply most of the scholarly workforce for Australia's university system, with some 70 per cent of doctoral graduates from Go8 universities taking up academic positions. The Go8 universities also set the standard within the national system of higher education and research and provide pathways for students, collaborative nodes for research and advanced scholarship, and professional development.

5. Go8 universities (along with CSIRO and other publicly funded national research agencies) provide the scale of capability (expertise + quality infrastructure) that forms the foundation of Australia's knowledge competitiveness.

Many of Australia's leading research infrastructure capacities including optical telescopes, high performance computers and synchrotron, are found at Go8 universities.

These five principles reflect the current situation and status of the Go8 universities and together provide a firm foundation from which they can develop in response to the issues identified in this paper. However, their ability to grow in a way which enhances the significant contributions they already make to Australia's innovation system will require appropriate policy settings and programs which recognise the importance of what they achieve and provide the resources necessary for them to achieve it.

Some conclusions

Universities work to release the potential of their students, providing the education they need to work in business, government and all other sectors of the community.[30] Universities are also critical components of the national research system, performing research which supports directly and indirectly, and across a variety of time scales, the wellbeing of the nation. Universities also add value as institutions, independently of their role in education and research, by providing a storehouse of knowledge and capabilities that other sectors can draw upon as they need them. Just as important is that universities, through their research and community engagement activities, play a role in defining and generating our national identity and, through the international significance of their research and education services, contribute to the international reputation of Australia.

In considering the various roles played by universities, the diversity of outputs they produce and the outcomes that they achieve, it is important to recognise that these are all interdependent. In effect, each university is a sub-system within the overall innovation system. It is not possible to change the way a university works to produce one kind of output without having an effect on the others. Developing policies and programs for change in universities requires an holistic approach which acknowledges the interdependencies and complex relationships that exist among the very wide range of services that each offers.

The strength and wellbeing of our universities is critical to national innovation and the overall effectiveness of our national innovation system. This also requires the universities to think broadly and to innovate in response to society's changing demands and the increased complexity of the challenges that Australia does and will face, while not moving back from their focus on excellence, on merit and on freedom of intellectual inquiry and public debate.

In accepting the critical importance of universities, policy analysts need to accept that the innovation system depends as much on realising the potentialities of people as it does on narrowly defined research outputs in science, technology, engineering and maths. The creativeness and risk-taking propensity of consumers are major contributors to national absorptive capacity, are major factors in being able to exploit new technologies and essential for an effective innovation system. Customers and consumers – whether proximate or ultimate- are the real drivers of an innovation system. Universities can play an important role in providing an education that promotes open mindedness, a preparedness to take calculated risks and an understanding that change can mean progress.

The independence, autonomy and self regulatory nature of universities provide the sound and necessary base from which they can respond to the changing and complex demands which business, government, society and students place on them. As a group, universities recognise the need to innovate, to improve their performance and to do this in a way that enables them to maintain their standards, in both education and research. If they are to do this effectively, they will need to specialise and this will require them to diverge from a single or standard model as they differentiate to meet the needs of the different niches that exist within the higher education and university markets – and which will become increasingly distinct as the student load increases.

One of the problems that universities confront is that some sectors can take a narrow view of the purpose of universities. In particular, business sometimes has a set of narrow expectations which ignore the broader and important roles of universities in serving society as a whole. Useful and productive debate about the purpose of universities needs to take place within a framework of realistic expectations rather than a narrow sectoral perspective which leads to impractical or idealistic demands.

30. In this role universities are an important export industry in their own right, providing education services to international students.

A graduate leaving a university will not have the knowledge and skills necessary to be fully effective in a firm because the technology, procedures and processes that support a firm's activities are local to each firm and require in-house training. A university can and does ensure its graduates have the ability to benefit from in-house training, and even to provide constructive criticism of in-house processes, but it cannot and should not meet the particular needs of each of Australia's nearly 2 million separate businesses. Moreover, a university has the responsibility to equip its graduates with the knowledge and skills that businesses do not yet understand that they need; and while the disciplines that universities support extend beyond those that business may see as relevant, it is necessary to recognise the important generic outcomes, rather than specific disciplinary knowledge, that can arise from any higher course of study.

As well as expressing concern that universities do not produce people with the particular skills they require, business sometimes objects to the nature and quality of university research. Again, this ignores the broader purpose of universities, that they serve sectors other than business and that their purpose is to complement not duplicate business. In particular, business complaints about university research fail to recognise the need for universities to serve a national purpose by operating on a time frame which extends beyond the immediate needs of business to create capabilities and opportunities for the future. In this context it is worth noting that attempts to forecast technological futures normally fail in two respects – they identify breakthroughs that never occur (nuclear fusion has been 20 years away ever since the 1950s); and they miss some of the most important, commercial and socially significant developments that actually happen (such as the internet). Predicting the future is difficult but universities work, not just to help create the future but also to ensure we have the capability to respond, no matter what the future throws up.

None of this is to say that universities cannot improve their performance. They can and must. However, as part of a broader innovation system, they need the support of other parts of this system if they are to innovate in a way that better supports the operation of the whole system. Part of this support needs to come from a wider recognition of the devolved nature of universities and a broader understanding that this forms part of their strength, reflecting their freedom of inquiry and their ability to go where opportunity and curiosity lead them. Business and government should not expect universities to operate as a single enterprise having central control because this would lead to a significant narrowing of national capability with potentially serious consequences for future national development.

One problem with the devolved nature of universities is that it makes it more difficult for businesses to identify where they might find the capabilities they are seeking. There is often no central, comprehensive register of capabilities or even of current research projects or of the specialised skills available. This is not always as big a hurdle as it may seem because businesses which perform research use the relevant literature and are aware of where the relevant research is taking place and of who is conducting it. However, this does not help the business seeking technical advice, specialised scientific services or access to sophisticated research equipment. Neither does it assist policy analysts seeking to identify whether Australia is lacking in capabilities that are becoming more important from a national perspective. The Go8 universities are addressing this problem through the development of a publicly available database (Australia's Knowledge Gateway) of the universities' research capabilities.

There are already many links between universities and business but there seems often to be a view that it is up to the universities alone to develop these links and to establish the networks that together make for an effective system. However, this cannot be a one-way process. While business will often seek out links with a university for a specified purpose – such as contract research on a defined problem to be completed by a specified time – business seems less inclined to develop strategic engagements with universities. Such engagement is not cost free but ongoing engagement building on a wide range of activities has the potential not only to develop a better appreciation of each other's roles

and responsibilities but also to lead to a greater responsiveness. There is a wide variety of activities that can support strategic engagement. They include membership of each other's governing bodies, participating in technical and other advisory panels, formal and informal discussions at departmental level of research plans and technical needs, two-way secondments, joint appointments, internships, visiting lectures, promoting visits to industry, and so on.

As part of an interconnected innovation system, universities and business are interdependent. They both make essential contributions to the wellbeing of Australia and in working more closely together they can benefit each other in a way that can only strengthen the nation's development. For such engagement to work, however, it is important that both sectors not only recognise but also respect the contribution of the other. Acknowledging the importance of innovation, the breadth of the innovation concept and the multiple ways in which universities contribute to innovation as well as the breadth of their responsibilities is one way of promoting this mutual understanding and providing the basis for stronger cooperation.

Attachment 1

The health innovation system

The Australian health innovation system encompasses all those institutions (and the people working within them) involved in initiating, developing and delivering education, training and research to improve health service delivery. These are spread across the government, private (including foreign-owned), higher education and non-profit sectors. The system also includes the consumers of health services, various regulatory agencies and the bodies responsible for monitoring and evaluating health service delivery. The system has strong and effective links with overseas organisations, both formal and informal. Framework policies and infrastructure, including the IP system, also have a major impact on how the overall system operates.

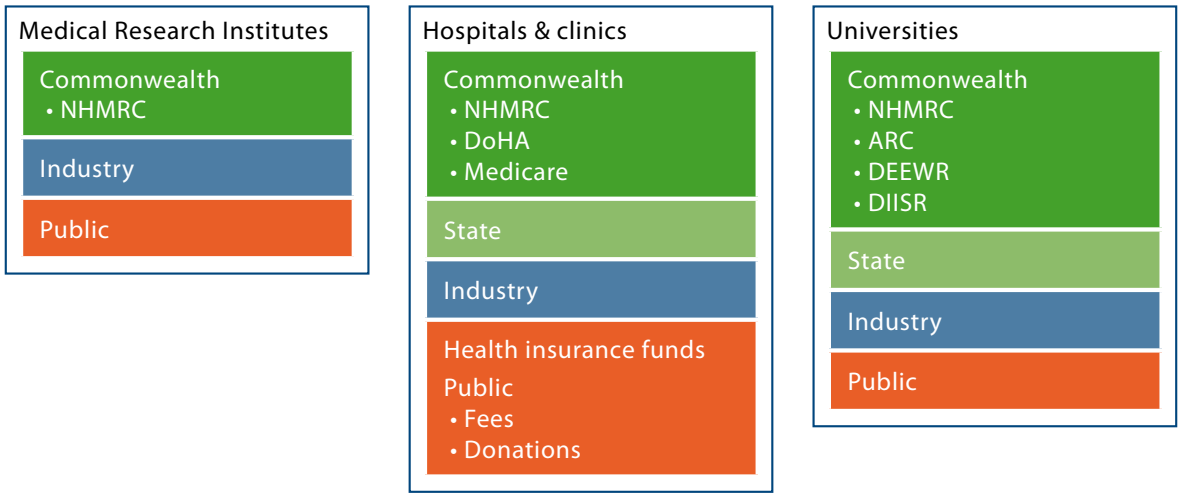
At the commonwealth level, the Department of Health and Ageing, the National Health and Medical Research Council, HealthWorkforce Australia, the Department of Innovation, Industry Science and Research, the Australian Research Council, and the Department of Education, Employment and Workplace Relations each has varying perspectives and interests.

At state and territory government level, health authorities are key players, as are offices responsible for science, medical research and related matters. There is also some local government involvement in health services.

Universities play a critical role in undergraduate and postgraduate education, and research. Medical Research Institutes also are critical to the undertaking of research and its translation to health services.

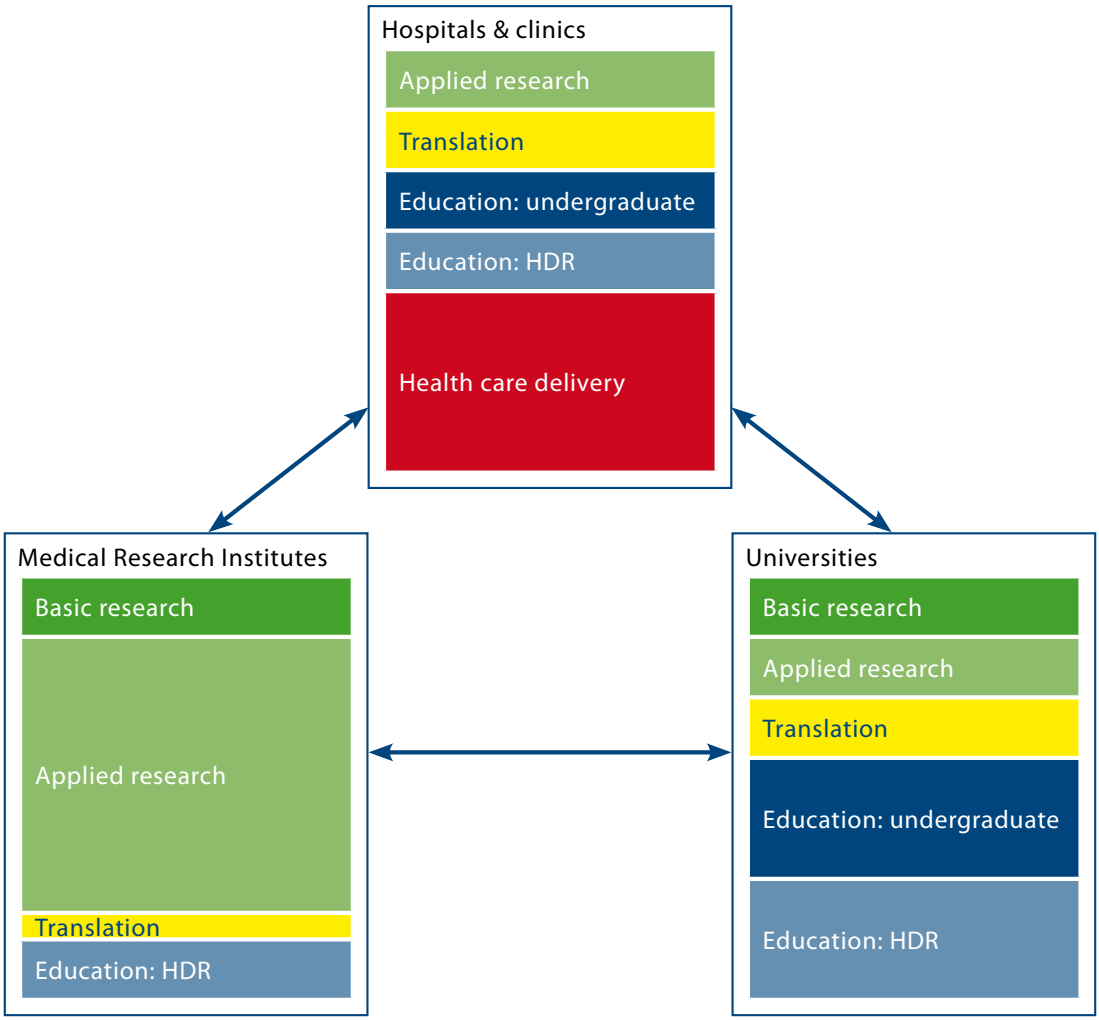
Other agencies like the Australian Medical Council and state and territory professional registration boards have an interest and exert influence. The professional associations, including medical specialist colleges, likewise play an important role. Charitable organisations play a strong role in the public profile of medical research in the community, in support and fund raising.

Health education, research and service delivery: funding sources



Health research, teaching and care: where it happens

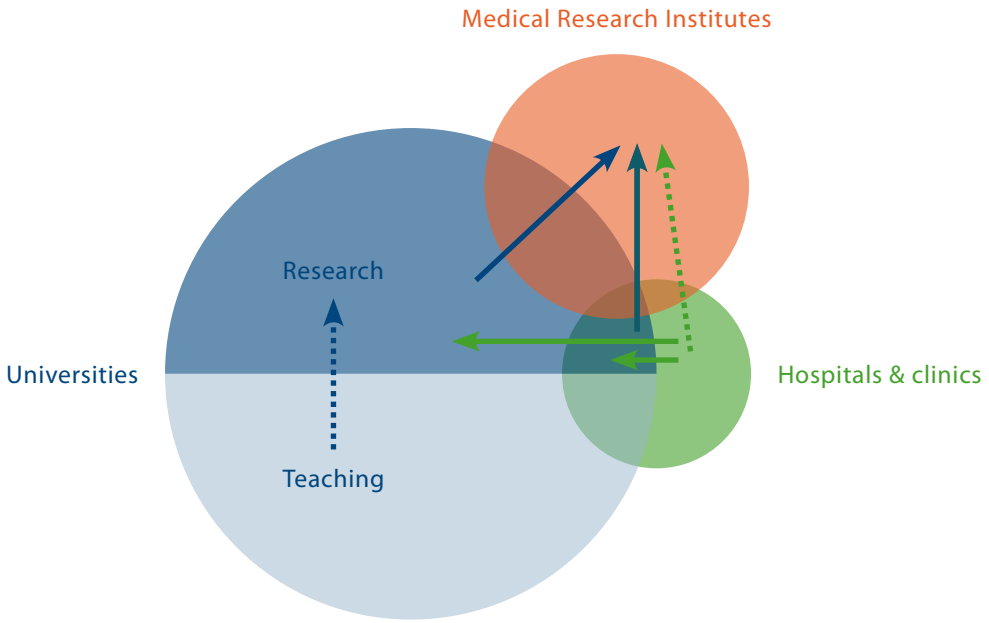
Health education and research activities take place in universities, large and small medical research institutes, public hospitals, private hospitals, super-clinics and smaller health centres and in the specialist and general practices where medical and other health students work to gain practical experience in health care delivery and health research. The private sector also plays an important and in some cases pre-eminent role in performing research and especially development.



Identifying research needs

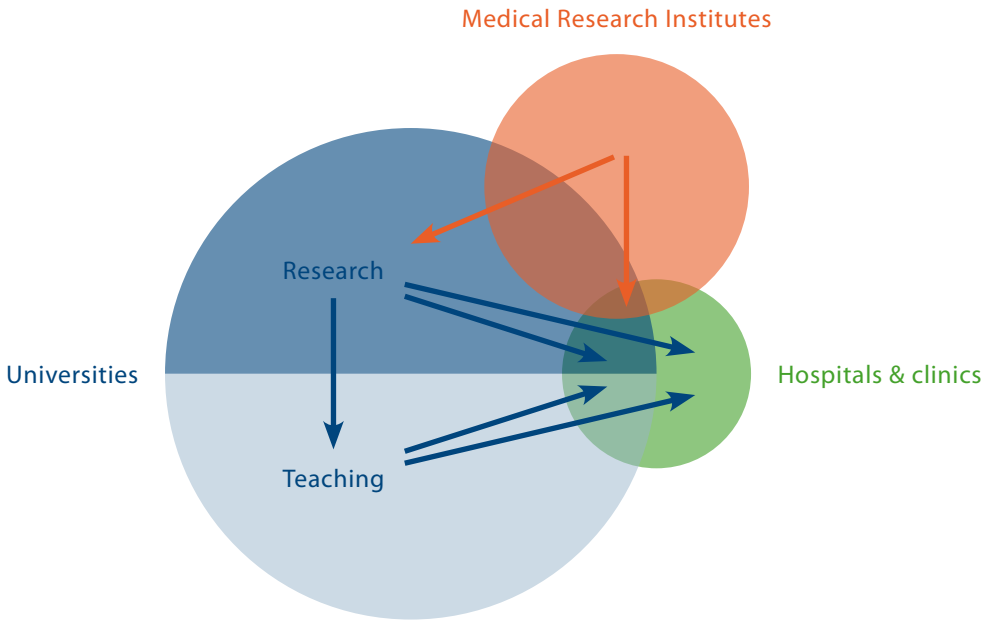
The process of identifying health research needs is complex. Much research flows from research already being undertaken – following lines of enquiry and experimentation, or trying alternative approaches, and through thinking and scientific discussion amongst researchers. Such research may reflect scientific opportunities rather than particular health priorities. Much research also arises from clinical cases, where existing treatments are inadequate or alternatives and improved techniques are explored. Depending on the nature of the research, ethical or other approvals may be necessary and the approval bodies form an important part of the innovation system.

Some research can be long term, based on understanding the fundamental processes behind a disease; other research can address more short term issues. Often a genuine solution to a health need will require a complex mixture of basic, strategic, applied and developmental work across different disciplines and timeframes. For example, it can be possible to attempt to develop a vaccine before there is any understanding of the molecular and physiological basis for the disease; or it is possible to develop strategies to reduce the disease incidence, if its mode of transmission is known, even when there is no understanding of how to treat the disease.



Translating research outcomes

The translation of research findings to patient care, and to teaching undergraduate and postgraduate students, is a critical outcome of research.



Clinical translational research takes place predominantly in universities, embedded in the hospitals and clinics but is not a straightforward process. For one reason or another there can be resistance to research findings (from health practitioners, other researchers, or patients); and obtaining the necessary regulatory approval for putting the findings into practice can be expensive, complex and time consuming. Moreover, there may ongoing requirements to monitor and continuously evaluate the intervention once health professionals do apply it and the administrative structures involved in these processes are also parts of the innovation system.

Attachment 2
Sources of ideas or information for business innovation[31]

	Employment size (persons)				Total
	0-4	5-19	20-199	200 or more	
Within the business or related company	57.4	61.7	69.8	82.6	60.7
Clients, customers or buyers	38.9	39.5	39.0	39.8	39.2
Suppliers	32.2	27.2	31.5	23.1	30.2
Competitors and other businesses in the same industry	29.9	29.9	33.6	36	30.4
Consultants	12.7	20.1	27.3	46.1	17.5
Universities or other higher education institutions	2.9	2.2	2.2	6.4	2.6
Government agencies	3.8	4.6	3.6	8.3	4.1
Private non-profit research institutions	0.9	1.1	1.1	3.5	1.0
Commercial labs/R&D enterprises	1.4	2.0	0.5	3.3	1.5
Websites, journals , research papers, publications	28.1	29.3	22.6	17.3	27.8
Professional conferences, seminars, meetings, trade shows	19.3	23.5	25.1	23.9	21.6
Industry associations	15.4	19.7	24.7	20.2	18.1

31. www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8158.02008-09?OpenDocument

Attachment 3

Innovation–Active Businesses: Skills used for innovative activities, by employment size, by industry, 2006-07[32]

Employment size	Engineering (%)	Scientific and research (%)	Information Technology (%)	Trades (%)	Transport, plant and machinery operation (%)	Marketing (%)	Project management (%)	Business management (%)	Financial (%)
0–4 persons	9.1	8.8	34.4	18.2	7.2	31.5	9.2	26.9	17.8
5–19 persons	8.5	6.9	35.2	21.5	7.8	35.9	8.8	33.7	23.6
20–199 persons	16.4	7.7	39.1	18.0	10.3	36.5	18.6	40.2	27.2
200 or more persons	31.1	15.0	54.6	17.0	13.9	37.3	39.9	47.8	42.9

32. www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8158.02006-07?OpenDocument

Attachment 4
Carnegie Classification of Institutions of Higher Education in the USA[33]

Numbers in brackets are the number of each institution.

Doctorate-granting Universities

Doctorate-granting Universities are those institutions that awarded at least 20 doctorates in 2003–04. These Universities are further classified by their level of research activity, as measured by research expenditures, number of research doctorates awarded, number of research-focused faculty, and other factors.

Research Universities (very high research activity) (96)

Research Universities (high research activity) (103)

Doctoral/Research Universities (83)

Master's Colleges and Universities

Master's Colleges and Universities are those institutions which "awarded at least 50 master's degrees in 2003–04, but fewer than 20 doctorates."

Master's Colleges and Universities
(Larger Programs – awarding at least 200 Masters-level degrees) (346)

Master's Colleges and Universities
(Medium Programs – awarding 100–199 Masters level degrees) (190)

Master's Colleges and Universities
(Smaller Programs – awarding 50-99 Masters level degrees) (128)

Baccalaureate Colleges

Baccalaureate Colleges are those institutions at which "bachelor's degrees accounted for at least 10 percent of all undergraduate degrees and they awarded fewer than 50 master's degrees (2003–04 degree conferrals)."

Baccalaureate Colleges – Arts & Sciences (287)

Baccalaureate Colleges – Diverse Fields (360)

Baccalaureate/Associate's Colleges (120)

Associates Colleges

Associates colleges are defined as institutions whose "highest degree conferred was the associate's degree or if bachelor's degrees accounted for less than 10 percent of all undergraduate degrees (2003–04 degree conferrals)."

Associate's – Public Rural-serving Small (142)

Associate's – Public Rural-serving Medium (311)

33. Taken from: http://en.wikipedia.org/wiki/Carnegie_Classification_of_Institutions_of_Higher_Education

Associate's – Public Rural-serving Large (144)

Associate's – Public Suburban-serving Single Campus (110)

Associate's – Public Suburban-serving Multicampus (100)

Associate's – Public Urban-serving Single Campus (32)

Associate's – Public Urban-serving Multicampus (152)

Associate's – Public Special Use (14)

Associate's – Private Not-for-profit (114)

Associate's – Private For-profit (531)

Associate's – Public 2-year Colleges under Universities (55)

Associate's – Public 4-year, Primarily Associate's (18)

Associate's – Private Not-for-profit 4-year, Primarily Associate's (20)

Associate's – Private For-profit 4-year, Primarily Associate's (71)

Special Focus Institutions

Special Focus Institutions were classified "based on the concentration of degrees in a single field or set of related fields, at both the undergraduate and graduate levels. Institutions were determined to have a special focus with concentrations of at least 80 percent of undergraduate and graduate degrees. In some cases this percentage criterion was relaxed if an institution identified a special focus on the College Board's Annual Survey of Colleges, or if an institution's only accreditation was from a body related to the special focus categories."

Theological seminaries, Bible colleges, and other faith-related institutions (314)

Medical schools and medical centers (57)

Other health profession schools (129)

Schools of engineering (8)

Other technology-related schools (57)

Schools of business and management (64)

Schools of art, music, and design (106)

Schools of law (32)

Other special-focus institutions (39)

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