TECHNOLOGICAL AND SERVICE INNOVATION IN WESTERN AUSTRALIA

Submission to the Inquiry by Economics and Industry Standing Committee

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Executive Summary

Mining industry expenditure on research and development in Western Australia has been particularly high and the benefits of this investment will continue to flow to the State and Australian economies now that this industry has moved from construction of facilities to its the production phase. However, the scale of mining industry research and development has obscured the comparatively low level of research and development in non-mining industries. Western Australia needs to encourage more research and development in these industries, including by educational institutions and Commonwealth agencies, to restore more balance in innovation efforts.

Engineers Australia agrees with the Chief Scientist that Australia needs to do more to build an innovation culture. All too often policies put forward as innovation policies are little more than quasi business assistance and eloquent bureaucratic solutions. A more substantive foundation is essential, one that focuses Australia's research and development on the practical challenges that industry needs to solve the major challenges facing the economy. Engineers Australia believes that concerted efforts by both State and Australian governments are necessary to turn this situation around. Australians have demonstrated a strong propensity for rapid take-up of new technological products and services and building an innovation culture on this foundation has considerable potential especially if commenced early during school years.

Engineers Australia believes that liberalising the business regulatory framework in which business operates is an important step, but unless there is continuous innovation future trend economic growth is likely to continue below past experience. Innovation is much more than invention because it also encompasses the practical application of new inventions and new methodologies in commercial market places. These issues are just as critical at State level as they are nationally.

Engineers Australia supports the establishment of an independent, national innovation board to set research and development priorities in a long-term, bi-partisan framework and to ensure that available funding are directed towards achieving these priorities. States and Territories each have unique characteristics that differentiate them and Engineers Australia believes that a Western Australian counterpart to a nation board is the most appropriate way to harmonize State and national priorities. It is Engineers Australia's view that innovation is a long-term, continuous process. In this context, short-term, politically inspired, changes to innovation policies are unlikely to be successful.

Education and training is crucial to an innovation culture. Research demonstrates that the decline of manufacturing and the rise of service industries should be viewed as complementary rather than autonomous changes. The related conclusion is that manufacturing matters because of its strong links to innovation. The economy is transforming away from vertically integrated businesses that undertake most steps in producing goods and services towards organizational networks of slimmed down, primary businesses partnering with an extensive group of service providers in arrangements driven by efficiency and working to performance standards. In this environment, the provision of specialised skills is king and innovation policy must be cognisant of all players and the roles they fulfill. In other words, innovation policy needs to focus on product-service packages rather than physical products as in the past.

Most jobs created in the economy in the recent past have required skilled workers, especially engineers. Engineering skills are essential to take inventions through various development stages to commercial goods and services. The contribution of education and training to innovation will be constrained unless falling participation in science and mathematics subjects are reversed. Innovation and the jobs of the future depend on analytical, problem solving skills in a rapidly changing digital world.

Innovation and Research and Development

Successive editions of the Commonwealth Treasury's Intergenerational Reports[1] have been criticized for their propensity to excessively reflect the political economy views of the government of the day. But putting aside these views, all four reports have a consistent central message. Productivity growth has been responsible for most past improvements in Australia's standard of living and this vital role will need to continue in the future if Australia is to maintain and, preferably, to continue to improve living standards. Engineers Australia agrees with the mainstream view of economists that productivity growth can be best achieved through innovation in an environment where economic infrastructure is a catalyst and not a barrier to growth.

Innovation can be achieved in numerous ways; formally through the application of research and development and informally through on-the-job learning by doing. The Bloomberg Innovation Index 2015[2] ranks Australia as 13th behind South Korea, Japan, Germany, Finland, Israel, USA, Sweden, Singapore, France, UK, Denmark and Canada. Bloomberg compiled its ranking by combining six indicators including:

- Research and development expenditure (Australia ranked 13th)
- The value added by manufacturing industries (Australia ranked 18th)
- The ten largest technology companies (Australia ranked 10th)
- Post-secondary education (Australia ranked 20th)
- Research and development personnel (Australia ranked 15th)
- Patents registered (Australia ranked 27th).

This brief account demonstrates that there are no "silver bullets" and that policies to foster innovation need to be multi-factorial.

The first of the Bloomberg indicators, expressed as research and development expenditure as a proportion of gross domestic product, has become a conventional measure of a country's efforts to become innovative. This was one of the measures adopted by the European Union's Lisbon Strategy which aimed to increase the competitiveness of Europe and develop it into the most knowledge based economy in the world[3]. The Strategy's objective was expressed as increasing research and development expenditure to three percent of GDP.

In this submission, we simply rely on research and development expenditure as a basic indicator of innovation. More specifically, Western Australia's share of national research and development will be compared to the State's share of gross domestic product to evaluate how the the State compares to Australia as an innovative economy. This measure is based on the view that research and development expenditure in Western Australia should be proportional to its share of gross domestic product; a higher share implies the State is doing better than Australia and conversely, a lower share implies that the State is not doing as well as Australia.

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[1] See achive.treasury.gov.au/igr/ and www.treasury.gov.ay/PublicationsAndMedia/Publications/2015/2015-Intergenerational-Report

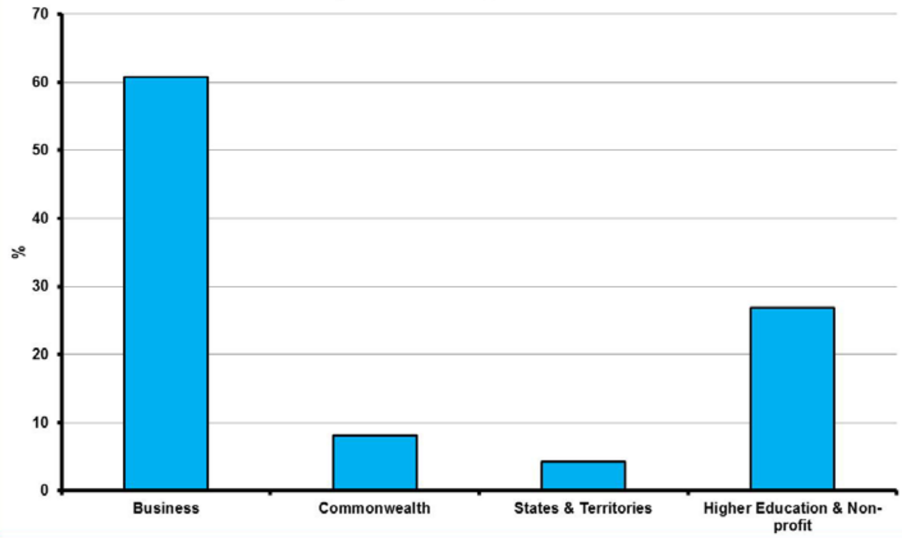
[2] See www.bloomberg.com/graphics/2015-innovative-countries

[3] See Penguincompaniontoeu.com/additional_entries/lisbon-strategy-and-europe-2020

Western Australia's Track Record

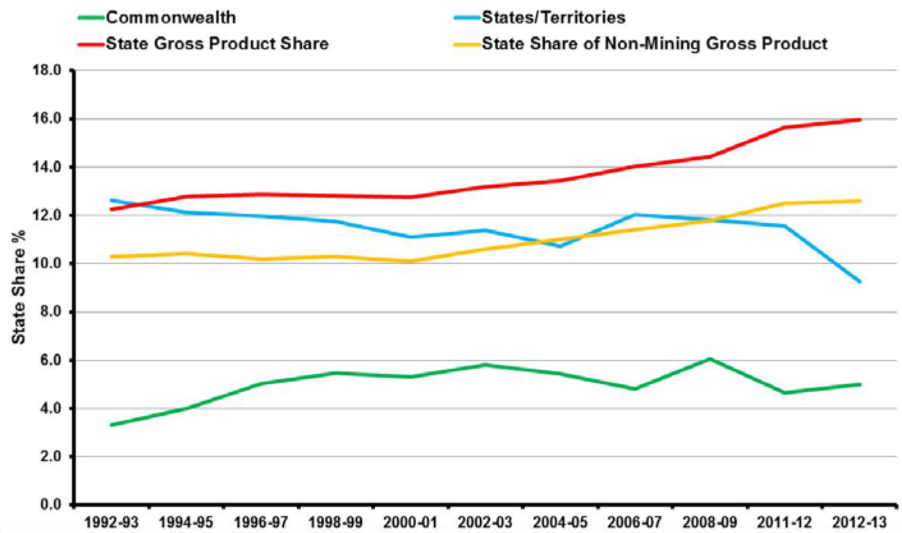
As is so often the case in Australia, consistent and comprehensive statistics for research and development expenditure are difficult to find. The ABS has released limited summaries of research and development covering all sectors of the economy, the latest was for 2008-09[4]. In the analysis that follows these statistics are used to establish the size of each sectors' contribution, illustrated in Figure 1, and other statistics are then used to examine trends in each component over time.

Figure 1: Research and Development Expenditure in Australia; Benchmark Summary of Contributing Sectors 2008-09



In 2008-09, Australian expenditure on research and development was $27.74 billion, about 2.4% of gross domestic product that year. Research and development by the business sector accounted for 60.8%, the Higher Education sector accounted for 24.2%, the Commonwealth Government for 8.1%, State and Territory Governments for 4.2% and 2.7% was contributed by non-profit entities (included with the Education Sector in Figure 1).

Figure 2: Government Research and Development Expenditure; Western Australia and Australia



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[4] ABS, Research and Experimental Development, All Sector Summary, Australia, 2008-09, Cat No 8112.0, 2010, www.abs.gov.au

The trends in Government Sector research and development are examined in Figure 2[5]. Here the green line shows Western Australia's share of Commonwealth research and development expenditure and the blue line the State's share of total research and development expenditure by the States and Territories. Two benchmarks are included in Figure 2. The first, the red line, is Western Australia's share of gross domestic product (State gross product as a percent of national gross product)[6]. This measure is comfortably higher than both measures of the State's share Government research and development and suggests that more could be done in Western Australia in this area; by the State government itself and through State government encouragement of greater Commonwealth research and development expenditure in the State.

The resources boom led to a large expansion of Western Australia's mining industry and the industry invested heavily in research and development. The extent of these changes are explored later in the Section, but to consider possible distortion of the comparison in the previous paragraph by these changes the second benchmark included in Figure 2 is Western Australia's share of Australia's non-mining gross product (the mining industry's gross product is excluded from both State and national gross product). This is the yellow line in the diagram. This benchmark shows that Western Australia has not received its share of Commonwealth research and development expenditure but, until recently, the State's share of research and development expenditure by States and Territories combined was higher than its share of non-mining gross product. However, since about 2007, the State's share in this measure has fallen to well below its share of non-mining gross product.

Figure 3: Business Expenditure on Research and Development, Western Australia and Australia

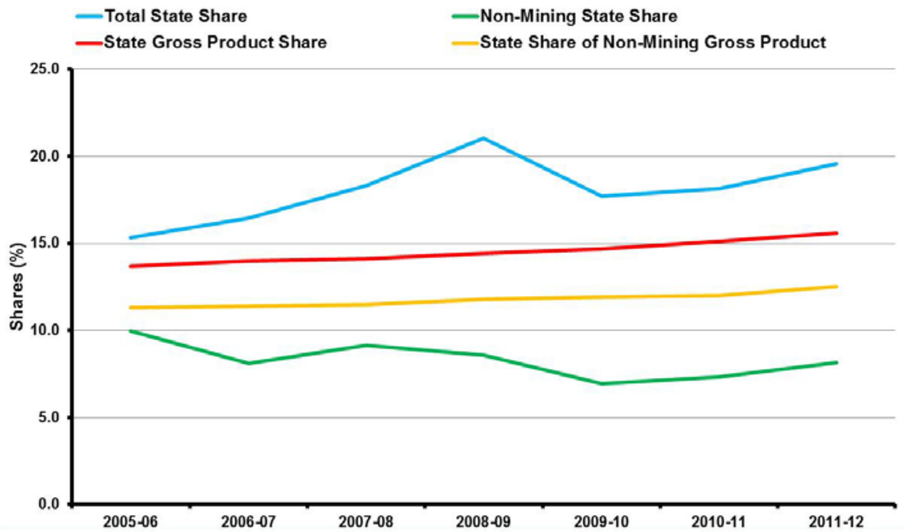

Figure 3 illustrates the corresponding trends for business research and development expenditure[7]. When the mining industry is included the comparison is between the blue line (which shows the Western Australian share of national business research and development expenditure) and the red line (which shows the State's share of gross national product. On the face of it, this comparison shows Western Australia in a very positive light, with the business sector spending far more on research and development in the State than the State gross product share.

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[5] ABS, Research and Experimental Development Expenditure, Government and Private Non-Profit Organisations, Australia, 2012-13, Cat No 8109.0, www.abs.gov.au

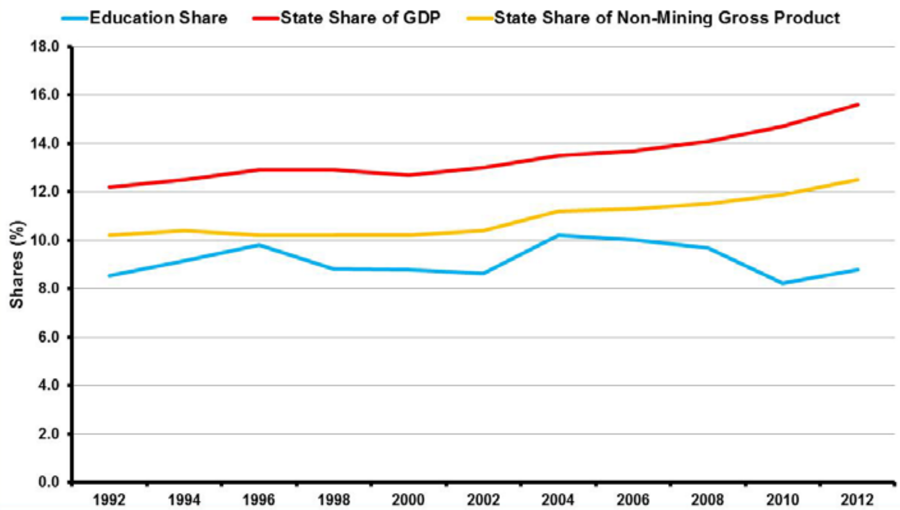
[6] ABS, Australian National Accounts, State Accounts, 2013-14, Cat No 52220.0, www.gov.au

[7] ABS, Research and Experimental Development, Businesses, Australia, 2012-13, Cat No 8104.0, www.abs.gov.au

However, the mining industry expenditure on research and development in Western Australia was particularly high, as high as three-quarters of the national spend in this industry and since about 2006 has accounted for well over sixty percent of business research and development in Western Australia. When the mining industry is excluded, the Western Australian share of national business research and development expenditure is shown by the green line and the State's share of gross domestic product is shown by the yellow line.

Excluding the mining industry turns the earlier conclusion on its head. In non-mining industries Western Australian business expenditure on research and development is much lower than its share of non-mining gross product and, more importantly, its research and development share has been falling. There is no doubt that the resources boom has contributed substantially to the Western Australian economy. However, during the boom these benefits obsured the imbalance in business research and development expenditure that developed. The benefits of mining related research and development expenditure will continue to flow to the State and Australian economies as the transition from construction to production phases of development proceeds, but Engineers Australia believes that the legacy of too low research and development expenditure in non-mining industries needs to be corrected as a matter of urgency.

Figure 4: Education Sector Research and Development Expenditure, Western Australia and Australia



Finally, Figure 4 illustrates how Western Australian research and development expenditure in the Higher Education sector compares[8]. The blue line in Figure 4 is the trend in the State's share of national research and development expenditure by this sector. Irrespective of whether comparison is with the Western Australian share of gross domestic product or with the State's share on non-mining gross product, research and development expenditure in the Western Australian Higher Education sector is below expectations.

In summary, an imbalance has developed in business expenditure on research and development that favours mining over other industries. Although, the large investment in the mining industry can be justified by the benefits flowing from this industry's expansion, the implication is that the level of research and development expenditure in other industries has been less than it should have been and the consequences are now becoming apparent. This imbalance is exacebated by low shares od Commonwealth Government and Higher Education sector expenditure and by the relative decline in State Government support since about 2007.

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[8] ABS, Research and Experimental Development, Higher Education Organisations, 2012, Cat No 8111.0, www.abs.gov.au

Policy Options

Economic Competitiveness

Innovation is the core of economic competitiveness. Engineers Australia believes that liberalising the business regulatory framework in which business operates is important, but unless there is continuous innovation the Reserve Bank Governor's observation[9] that future trend growth may be less than in the past could come to pass. Innovation is often defined as productivity enhancing technological change[10], a substantive process that depends on both basic and applied research and development and on the commercialisation of new ideas, processes and products. Innovation often begins with invention, but also encompasses the practical application of new inventions and new methodologies in commercial market places. These issues are just as critical at State and national level.

Engineers Australia agrees with the Chief Scientist that Australia needs to do more to build an innovation culture. All too often policies projected as innovation policies are little more than quasi business assistance and eloquent bureaucratic solutions. A more substantive foundation is essential, one that focuses Australia's research and development on the practical challenges that industry needs to solve the major challenges facing the economy. Engineers Australia believes that concerted efforts by both State and Australian governments are necessary to turn this situation around. Australians have demonstrated a strong propensity for rapid take-up of new technological products and services and building an innovation culture on this foundation has considerable potential especially if commenced early during school years.

At present there is a confusion of different mechanisms to promote innovation, to set research and development priorities and to ensure that available research funding is directed towards these priorities. The difficulties with this approach include:

- Issues that require attention over the medium to long-term are caught up in short-term political cycles.
- Several innovation strategies have been developed by different governments over the past two decades with remarkably similar objectives, reflecting the views of the government of the day, but have achieved little effective progress.
- Programs aiming to promote innovation are typically too small to matter, are prone to rapid change and are too numerous to be comprehended by the people they aim to assist.
- Research and development funding is not targeted to identified priorities and funding directions adopted by different agencies often conflict.

Engineers Australia believes that Australia needs an independent innovation board along the lines recommended by the Chief Scientist[11]. Productivity enhancing technological change is a long-term process and in the Australian political context requires, and deserves, bi-partisan support. This was the key missing ingredient in past innovation strategies. It also deserves complementary action by both levels of government to ensure there is shared focus and coherence in innovation policies. Engineers Australia accepts that a "one size" approach is unlikely to adequately consider differences between

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[9] Glenn Stevens, Issues in Economic Policy, address to Anika Foundation Luncheon, 22 July 2015, www.rba.gov.au

[10] See for example Michael Oliver's blog Contemporary Economic Development, https://comparativeeconomicdevelopment.wordpress.com/2013/06/01/producing-prosperity-pisano-and-shih/

[11] Chief Scientist, Science, Technology, engineering and mathematics: Australia's Future, September 2014, www.science.gov.au

jurisdictional economies, but complementary arrangements offer this potential as well as the capacity to draw on work carried out in other jurisdictions.

The Commonwealth government has announced a growth centre initiative[12] as part of its innovation and competitiveness agenda. Although this approach falls short of the medium to long-term focus and independence preferred by the Chief Scientist's recommendation, Engineers Australia agrees that this initiative is an important step towards the development of "industrial commons" as envisaged by Pisano and Shih[13]. Western Australia already has an excellent example of "industrial commons" in the Australian Marine Complex at Henderson[14]. The essence of "industrial commons" is the way in which cooperation between enterprises with shared interests feed off each other. Rebuilding "industrial commons" is an important aspect of not strategies designed to turn around the loss of competitiveness in the US economy. In our view, further complementing the ship building example and building industrial commons in other priority areas would be important steps. However, without some government help and the adoption of a long term, bi-artisan innovation strategy these changes are unlikely.

Education and Training

Engineers Australia believes that building an innovation culture begins at school. However, successive Australian Governments have not succeded in halting the falling participation in science and mathematics subjects at school. Considerable promise has been attributed to the national schools curriculum, but despite the twenty years of Commonwealth-State negotiations leading to an agreement, the curriculum itself will not reverse falling participation in science and mathematics at school. More substantive action is necessary, particularly by State governments which have constitutional responsibility for school education.

Competent practicing engineers are indispensible to an Australian future in which innovation drives productivity growth. Engineers are employed in practically every Australian industry and with the increasing sophistication of the economy, jobs for engineers are opening up in industries where previously no engineers were employed. Without engineers, cities would grind to a halt, modern medical diagnostic techniques would not be possible and technological change simply would not happen. The education and training of Australian engineers depends on schools graduating well rounded year 12 students competent in the foundation subjects for engineering degrees and diplomas.

For some time Engineers Australia has argued that Australia needs to do more to produce its own engineers and to reduce its reliance on skilled migration. Census statistics demonstrate that between 2006 and 2011, over 70% of the increase in Australia's supply of engineers was from skilled migration with the result that the majority of Australia's engineering labour force is now overseas born. No other profession is in this position[15].

Strong skilled migration policies offer important benefits including adding to economic demand, increasing the average standard of education in the labour force, introducing the benefits of diversity and supplementing the output of our educational institutions to build national engineering capacity. However, there are also risks in depending too much on skilled migration. The developing economies from which Australia sources its engineers are also aiming to develop and build their economies through technological progress. These efforts are uneven at present, but in time the demand for engineers will increase in source countries and undermine Australia reliance on skilled migration. Risk mitigation can

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[12] Department of Industry and Science, Industry Growth Centres Initiative, www.industry.gov.au

[13] Gary P Pisano and Willy C Shih, Restoring American Competitiveness, Harvard Business Review, July-August 2009

[14] http://www.australianmarinecomplex.com.au

[15] See Engineers Australia, The Engineering Profession: A Statistical Overview, Eleventh Edition, 2014, www.engineersaustralia.org.au

be achieved by growing Australia's home grown engineering capacity to lessen dependence on skilled migration.

The critical status of science, technology, engineering and mathematics (STEM) in schools is underlined by the strong demand for people with engineering qualifications in occupations unrelated to engineering. The strength of this demand means that only 62% of people with recognised engineering qualifications in Australia are employed in occupations with an acceptable connection to engineering; the rest respond to the demand for technologically literate and analytically inclined people elsewhere in the economy. The measure developed by Engineers Australia is as much a measure of unsatisfied demand for STEM literacy in the economy as it is a measure of retention in engineering[16].

A national innovation policy requires strong participation from the business sector to assist improvements in education and training and through the innovation process itself. Engineers Australia undertakes the accreditation of university courses in engineering throughout Australia. Accreditation guidelines include a work experience component for engineering students in later years of their courses. Universities consistently have difficulties in finding sufficient work experience places for students, yet employers readily complain that engineering graduates are not work ready. Engineers Australia believes that business organisations and leaders need to do more to increase business participation in the education and training of the STEM labour force and pressure from the Western Australian government in this regard could assist a new start.

The Commonwealth government has flagged support a COAG National STEM in Schools Strategy[17]. Engineers Australia supports this type of complementary action provided there is a balanced approach to STEM, one that gives similar weight to mathematics, science and engineering. Few Australians appreciate the key role that engineering has in a modern economy and society and this must change if Australia is to develop an innovation culture and the best place to initiate such change is during formative years. Our view is informed by the 2008 DEEWR survey on changes in awareness and understanding of science, engineering and technology among school children, their parents and the community. Two key results from this survey were:

- Only 9% of survey respondents could think about a science, engineering and technology profession other than medical researcher, doctor or computer programmer.
- Young people from 16 to 25 years, an age group most important to future study and employment decisions, were particularly uninformed about where people with science, engineering and technology skills are employed.

Engineers Australia is directly endevouring to improve understanding of engineering among school children through its EngQuest program which aims to nuture science and engineering capabilities from a young age. It is an on-line outreach program that connects teachers and students with volunteer engineers. The EngQuest web-site has three entry portals;

- The Teachers' portal: teachers can register for free and once registered can access the teachers portal via passwords to obtain background information, resources, project plans and other support to conduct engineering projects in their classroom. Curriculum supports provides direct links to the Australian curriculum in science, mathematics and technology. It is not necessary for teachers to be experienced in these areas because the support available provides the necessary guidance.

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[16] Op Cit.

[17] Australian Government, Vision for a Science Nation, Consultation Paper, June 2015, https://consult.industry.gov.au

- The Students' portal: provides access to games and activities and to information on projects (see below). The student portal also has an "ask an engineer" portal which students can use to establish interaction with real engineers for advice on projects and other issues.
- The Volunteer portal: provides access for volunteer engineers to overview projects being undertaken by students, to provide advice to them and to respond to questions asked by students.

The link to the EngQuest web-site is www.engquest.org.au .

The program offers students the choice of eleven projects, each of which can be conducted at three levels to accommodate lower primary, primary and lower high school (middle school) students. Some of the more popular projects include construct a solar cooker, construct a water wheel, construct a catapult and construct a straw bridge. The program design is flexible to accommodate teacher needs and projects can be undertaken quickly and simply or with greater complexity over a longer period depending on teacher curriculum requirements. Project materials are easy to find in the school environment or at supermarkets and all materials are recyclable.

In 2011, EngQuest facilitated 908 teachers in 688 schools to involve 41,912 students in projects, assisted by 144 volunteers. The number of teachers and schools fell slightly in 2012, to 870 and 638 respectively, but the number of students involved increased to 42,611 and the number of volunteers increased to 302. Last year, the program experienced a large increase in participation. The number of teachers increased to 1,847 from 1,530 schools and the number of students exceeded 100,000 for the first time reaching 109,552, assisted by 177 volunteers. In 2014, about 112,000 students participated.

In Western Australia, Engineers Australia hosts the EngTalk program which coordinates sixty engineering volunteers to go to high schools to promote engineering careers to students[18]. Engineers Australia also hosted an Engineering Interactive Zone at the SkillsWest Expo 21-23 August. Activities included the display of a 3 D printer and drones and were conducted by Robogals and Engineers Without Borders complemented by Engineers Australia members who talked to students about engineering experiences and careers[19].

Engineers Australia plans to continue with Engquest, but this contribution is limited by the capacity of our organisation. One way to offset this limitation is endorsement of EngQuest and other programs such as the CSIRO program highlighting mathematics and science by State authorities to schools in their area of responsibility.

Research

The Chief Scientist has recommended that Australia adopt a long-term research plan to support a national innovation strategy. We believe that Western Australia should establish a complementary long-term research plan. The key issue is continuity; stop-start policies and programs with short time horizons are not conducive to useful research and development. We believe that a long-term research plan, balanced between the core sciences and engineering and technology is an essential ingredient for innovation. That said, long-term is longer than the budget forward estimates period and/or the political cycle.

[18] www.engineersaustralia.org.au/western-australia-division/schools-program

[19] www.skillswestexpo.com.au/whats/show-highlights/engineering-interactive-zone/

Engineers Australia is a strong supporter of evidence-based policy. With this in mind, Engineers Australia believes that there is a major information gap in information informing discussions about innovation. This was one of the key points made by Pisano and Shih in their pathbreaking analysis of American competitiveness[20]. When these authors examined trends in research and development funding, they found that the historical even split between basic and applied research had changed had changed. As well as real falls in funding in each category, applied research fell more sharply. The earlier section in this submission shows that similar problems have developed in Western Australia. Engineers Australia believes that an innovation strategy should be informed by continuous analyses of research and development trends; the contributions of government, business and education sectors and the contributions from different industries. Without this information change will be hit and miss and effective progress very difficult.

Infrastructure Availability

Engineers Australia is strongly committed to the view that infrastructure is the essential enabler of Australian productivity growth, which in turn is essential to preserve and improve Australia's standard of living. This connection depends on infrastructure being fit for purpose and the flow of infrastructure services remaining ahead of population growth. Engineers Australia has drawn attention to problems with Australia's infrastructure in its Infrastructure Report Cards, the first of which was released in 1999[21] with updates in 2005 and 2010.

Engineers Australia believes that both how existing infrastructure is managed and the technology embodied in new infrastructure are important. It is not always appropriate to build new infrastructure but incorporating smart ICT into existing infrastructure assets and systems can lead to significant productivity improvement. Leveraging the investment in the NBN by targeted ICT investment in existing infrastructure is an approach that can yield rapid results. As new infrastructure assets are required, the incorporation of smart ICT features can add to these benefits.

These issues were critically examined by the UK Royal Academy of Engineering in 2012.[22] The Academy offered this definition; "a smart system uses a feedback loop of data which provides evidence for informed decision-making. The system can monitor, measure, analyse, communicate and act, based on information captured from sensors."[23] Smart systems can function at different levels including collecting information to facilitate the design of the next generation of infrastructure, collect and analyse information that facilitates human operation of infrastructure assets and collect and analyse information to allow infrastructure assets to operate automatically.

In engineering, there are numerous applications of modern digital technology covering all walks of life. Some examples include:

- Asset management and systems management and optimisation
- Managing the structural health of most infrastructure facilities
- Intelligent infrastructure systems, including transport systems and energy systems

[20] See footnote 6.

[21] See https://www.engineersaustralia.org.au/infrastructure-report-card

[22] Royal Academy of Engineering, Smart Infrastructure: the Future, January 2012, www.raeng.org.uk

[23] Op cit, p6

- Improving freight and port logistics
- Improved monitoring of the physical environment including estimating sea levels in coastal areas, reducing soil erosion and monitoring groundwater
- Improving construction productivity and improving building energy efficiency
- Communications systems, including broadband networks and wireless technologies.
- The application of large data base analytics for prediction and evidence based management to improve infrastructure productivity.
- Simulation using spatial information in the overall planning of infrastructure, including information modelling of infrastructure integration across whole cities.

The key to the productivity of smart infrastructure is feeding back into operations and design lessons acquired from the analyses of data describing the operation of existing assets. These lessons can reduce asset replacement, reduce the need for redundancy engineered into the asset to guard against unforeseen events and improve effective operation through better maintenance.

Smart infrastructure may be more expensive in the short run while offering far greater benefits in the long run. This means that public sector procurement arrangements should avoid decision making based on short-term acquisition costs and instead favour decisions based on life time benefits and costs. In the private sector, procurement decisions often relate to asset payback periods and similar considerations apply.

The demands of smart infrastructure emphasize the importance of engaging the appropriate engineering, ICT and risk management skills to ensure that inter-connections between infrastructure systems do not present new sources of vulnerability that could lead to system failure. Infrastructure designers, developers and managers need to be concious of the roles played by back up systems to mitigate the consequences of failures.

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