Engineering Talent Development Portfolio
An Innovative Framework to Design Lifelong Engineering Learning

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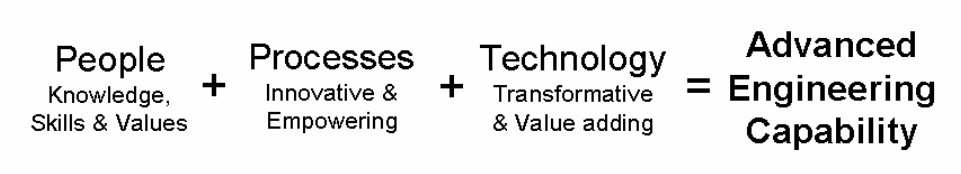
INTRODUCTION

The imperatives of innovation and globalization require holistic approaches to developing advanced engineering capability. Over the past decade or more there has been growing concern in the developed economies about these issues [1] and national strategies [2] to tackle them and numerous reports on reform in engineering education [3-5]. More recently concern over a shortage of engineers in developed economies have emerged [6]. This is combined with a recognition that the problem begins very early in the education system [7-8].

The reality is that all of these are parts of a much more complex system of initiatives that together may help revitalize and advance the engineering capability in the industrial economies. There are many cutting edge programs in schools and informal education, innovation in engineering education in university and creative continuing professional development initiatives in industry that are each addressing parts of the overall problem. What is missing is a coherent framework for analysing the totality of all these initiatives and for understanding how the system of lifelong education as a whole can be tuned to better develop and retain engineering talent from K (kindergarten) to Grey.

1 CHALLENGES FOR ADVANCING ENGINEERING CAPABILITY

Advanced engineering capability is the combination of three interdependent elements: (i) people with appropriate knowledge, skills and values; (ii) supportive processes that empower and foster innovation and (iii) access to transformational technology that adds value to both the conduct of engineering work and to the products, systems and engineering projects that are delivered.



Achieving such engineering capability is being challenged on three fronts: (i) changes in education from K-20, (ii) changing workforce demographics and (iii) the changing nature of work practices.

1.1 Challenges in Engineering Education

There have been numerous reports on the perilous state of K-12 education in the US in terms of developing the core capabilities to success at post-secondary education so as to enable business and industry to compete in a global business environment. There have also been some disturbing reports indicating that the preparedness of college graduates (including engineers) do not meet the expectations of industry. This highlights the need for concepts like graduate attributes and competencies in relation to education and for work to be more firmly grounded in a robust theoretical framework.

In other developed economies there have been numerous reports over the past decade or more about the need for reform in engineering education and for new strategies to attract the next generation of young people to careers in so called STEM disciplines. While this generation is keen to use the latest high-tech products and services, they seem less interested in being part of the process of innovating and creating new technologies. Almost the opposite is true of developing countries where engineering is often seen as a pathway to a respected professional career and a way to be part of nation building [9].

1.2 Changing Workforce

The challenges associated with the changing workforce in developed countries include the potential loss of industry knowledge that results from retirements of the baby-boomers, global competition for talent, issues around of skilled migration, the global mobility of professionals (brain circulation rather than brain drain), generational change around “millennials”, changing societal mores, changing employee career expectations and work-life fit.

In the emerging BRICS economies and developing countries the changes in workforce are almost the reverse but nevertheless equally profound. The issues are more around recruiting mid to upper career nationals who have the relevant experience, often gained in developed countries, and have them lead and mentor the large number of relatively inexperienced nationals who are being graduated in engineering either in-country or from universities around the world. .

1.3 Changing Work Practices

Business practices have undergone significant changes that will impact on the development of talent. Examples include; the innovation imperative, managing risk, the increasing complexity of projects, products and systems, disruptive technologies, working globally, new business models based on working relationally (rather than in

an adversarial fashion) including joint ventures and public-private partnerships, increased working with and across other professional disciplines, working sustainability (from cradle to grave), issues around permission to operate in a community, and knowledge retention and sharing and lessons learned from practice.

2 TALENT DEVELOPMENT PORTFOLIO

In industry sectors dependent upon STEM knowledge and skills, there are many and diverse talent development initiatives that are endeavouring to address one or more of the three challenges – education, workforce and work practices. It is extremely difficult for industry sectors, much less individual firms, to get a handle on all that is happening, what works, what is relevant to them, how they can become effectively engaged in one or more of these opportunities, if they should develop a new initiative or if they should tap into something already underway.

To overcome this problem, a novel analytical framework, the Engineering Talent Development Portfolio, is proposed as a means to map the diversity of types of capacity building programs. It is a powerful analytical tool for seeing the patterns in the many different types of capability building programs that exist and enables firms to visualize their talent development offerings in a larger context.

The Portfolio presents eighteen distinct strategies (one per cell in the diagram) for building capability (e.g. cross-sector professional development networks). Each of these strategies occurs at the intersection of one of six approaches to talent development (e.g. culture change) and one of the three major challenges (e.g. workforce challenges). See Figure 1.

Six Approaches to Developing Talent

Three Challenges for Talent Development	Community Engagement	Practice-based Learning	Mentoring and Coaching	Knowledge Sharing	Cultural Change	Innovation & R&D Networks
Tackling Education Challenges	*Next Generation Engagement*	*Internships & COOP Programs*	*Mentoring Students & Academics*	*Collaborative Education Programs*	*Inter-disciplinary Collaboration*	*Practice-based R&D Programs*
Tackling Workforce Challenges	*Business / Community Partnerships*	*Graduate & Professional Development Programs*	*Workforce Mentoring & Coaching Schemes*	*Generational Exchanges and Retention Schemes*	*Cross-sector Professional Development Networks*	*Technical Skills Development Programs*
Tackling Work Practice Challenges	*Strategic Industry Partnerships*	*Sector or Supply Chain Secondment Schemes*	*Sector Mentoring Schemes*	*Broad-based Communities of Practice*	*Cross-sector Exchange Programs*	*Technology Exchange Networks*

Figure 1 Engineering Talent Development Portfolio

Each of the eighteen strategies can be broken down into more specific types of programs. For example, the strategy of *cross-sector professional development networks* includes such things as ethics programs; networks for women professionals; global competencies forums; sector or cross-sector leadership programs. In turn each of these types are composed of many specific programs each with particular attributes. These programs can be tactical and/or strategic in nature.

Thus the Talent Development Portfolio is a "*strategy of strategies*" approach. Many of the present gaps in talent development strategies revealed by the tool can be achieved by leveraging current and emerging business practices including communities of practices, professional social networks, peer mentoring, reverse sabbaticals, work-life fit, time-to-try projects, and immersive work and learning environments.

3 PRACTICAL APPLICATION OF THE PORTFOLIO

The Engineering Talent Development Portfolio (originally called the Capability Strategy Matrix) was the organizing framework behind the Australia Engineering Capability Network (AECN). This network was comprised of employers of engineers, industry associations, professional societies, elementary, middle and high school teachers and associations and government agencies. The engineering sectors represented included defense, aerospace, construction, manufacturing, resources, engineering design and utilities.

Over a three year period, the ACEN conducted a national review of a wide variety of programs that ranged from fostering increased participation in the STEM careers aimed at school children through to senior engineering executives dealing with cultural change. A total of 250 distinct in-company and sector–wide programs designed to develop STEM talent were identified and 100 of these were developed as case studies using a rigorous, seven step protocol.

The following sections list illustrative examples of programs that respond to one of the three challenges using one of the six approaches.

3.1 Community Engagement Approaches

Challenge	Strategy	Examples
Tackling Education Challenges	Next Generation Engagement	Design and other Competitions Summer Programs Practical Careers Advice (Changing the Conversation) Integrated Science/ Maths / Engineering Curricula Entry Scholarships In-Service Teacher Programs
Tackling Workforce Challenges	Business/ Community Partnerships	Engineers in community projects Engineers in relief organisations Community skills development programs
Tackling Work Practice Challenges	Strategic Industry Partnerships	Strategic industry partnerships Community & regional partnerships

3.2 Practice-Based Learning Approaches

Challenge	Strategy	Examples
Education	Internships and COOP Programs	Internships and Placements Coop Education Project/problem based learning
Workforce	Professional Development Programs	Inter- or Intra-Sector Graduate Exchange Programs Practice-based Masters Programs Inter- and Intra-Sector Professional Development Programs
Work Practices	Sector or Supply Chain Secondment Schemes	Staff exchange or secondment schemes across a supply chain or amongst a group of industry stakeholders

3.3 Mentoring & Coaching Approaches

Challenge	Strategy	Examples
Education	Mentoring Students and Academics	Industry Mentors for Students Cross-institution Mentoring for New Faculty Peer Mentoring across Disciplines
Workforce	Workforce Mentoring & Coaching Schemes	Mentoring across Organizational Boundaries Inter-generational Coaching / Exchange Schemes Sector / industry Mentoring Schemes Mentoring / Coaching that Foster Diverse Experiences
Work Practices	Sector Mentoring Schemes	Intra and Inter-Sector Mentoring Schemes Work Exchange Schemes

3.4 Knowledge Sharing Approaches

Challenge	Strategy	Examples
Education	Collaborative Education Programs	Cross-university exchange / education programs Interdisciplinary and Thematic Research Networks Clearinghouses of T&L Materials
Workforce	Generational Exchanges & Retention Schemes	Networks of young professionals Industry-wide skills retention schemes Inter-generational learning compacts Industry /sector
Work Practices	Broad Based Communities of Practice	Intra-industry communities of practice Thematic National Groups (e.g. Technical Societies; SIGs) Focused Industry Summits

3.5 Cultural Change Approaches

Challenge	Strategy	Examples
Education	Inter-disciplinary Collaboration	Engineer-in-Residence and Reverse Sabbatical program Interdisciplinary Research Consortia and Networks Team teaching with non-engineering disciplines
Workforce	Cross-sector CPD Networks	Cross-cultural Ethics & Values Programs Women and URM in Engineering Practice Networks Global Engineering Competencies
Work Practice	Cross-sector Exchange Programs	Industry / Sector Programs on Alliance Contracting Industrial Sabbaticals or Exchange Schemes Cross cultural Leadership programs

3.6 Innovation Network Approaches

Challenge	Strategy	Examples
Education	Practice-based R&D Programs	Embedded Research for Graduate Students in Industry Short immersions of PG students in industry
Workforce	Technical & Entrepreneurial Skills Development	Industry / Sector Technical Skills Development Programs Education Programs in Collaborative Research Centres Entrepreneurship Boot Camps and Sabbaticals
Work Practice	Cross-sector Exchange Programs	Pre-Competitive R&D Consortia Interdisciplinary R&D centres and institutes Technology Awareness & Application Programs

3.7 Success Principles

These case studies identified five success principles.

The first principle, encourage entrepreneurship, recognizes the need to affirm and support the creative energy of many groups engaged in sector-wide talent development programs. It is imperative that nothing impede activities that are already being done well. Local entrepreneurship can be encouraged through a franchised national program to provide coordination, advice and support for the wide variety of capability development initiatives.

The second success principle, share ownership, is about having multiple stakeholders involved in the conception, design, implementation, evaluation and continuous improvement of capability development initiatives. Incorporating different yet complementary perspectives are precursors for sustainability through meeting the expectations of all the stakeholders.

The third principle, evaluate impact, highlights the need for systematic measurement of outcomes. Sharing such performance data widely informs new programs about ways to be successful. Evaluation is made much easier in cases where a program has been designed around a relevant learning, social or motivational theory or other appropriate conceptual framework.

The fourth principle, replicate success, builds logically on the first three. While in the short term there may be competitive advantage in keeping successful talent development programs proprietary, the increasing permeability of good ideas across firms and even sector boundaries that will characterize business going forward suggest that this is a problematic approach in the longer term. One strategy for replication is to franchise highly successful programs. This would allow local adaptation while not consuming precious resources on developing program materials, promotion and marketing and other non-direct value adding activities.

The fifth success principle, report transparently, combines two ideas; the need to disseminate and share information on successful capability programs widely and freely and to ensure that this information is objective and authoritative so that people can make evidence-based decisions.

4 DISCUSSION

The real value of the Engineering Talent Development Portfolio is in its scalability; the ability to capture and see patterns in programs at multiple levels of granularity. You can move up in levels of abstraction to see the “big picture” or drill down to see the details.

The portfolio is both an analytical tool and a planning tool. It can be adapted for use at a firm level or a sector level as a diagnostic tool to detect gaps and to foster innovation in creating more coherent and comprehensive talent development programs. At a firm level, it can assist in identifying talent development programs external to the firm that are part of the talent supply chain and thus find opportunities to better engage with and benefit from such programs.

At a sector level it highlights opportunities to build new programs that will increase the quantum, demographics or quality of professional talent available. This is often done by adapting successful programs from other sectors or even creating cross-sector programs that avoid direct competition with others in your industry sector. It is also a very powerful tool for government and policy makers to look systemically at the “talent chain” or the “talent circulation” and enhance the retooling of talent for emerging commercial areas.

The Engineering Talent Development Portfolio provides a means to proactively approach this inevitability from a strategic perspective. Nobody wants to develop talent only to lose it to competitors or to other sectors that offer more attractive compensation packages. The future of talent development is bound up in collaborative approaches where engagement in the process is a prerequisite for success in having access to the best talent.

5 SUMMARY AND ACKNOWLEDGMENTS

Engineering talent development is becoming an increasingly complex, interdependent process; short term solutions will not lead to sustainable outcomes. It must be viewed as a long-term, whole-of-career portfolio of strategies where many organizations in multiple sectors invest in individuals and teams and from which all potentially benefit.

It is imperative that we find systemic, game-changing ways to grow the global talent pie and not simply slice the existing one into ever more pieces. The Engineering Talent Development Portfolio affords unique insights which can guide firms, industry sectors and policy makers to counter the increasing intensity of the global “war for talent”, especially in engineering-based industry sectors.

The Engineering Talent Development Portfolio engages competitors and stakeholders in collaborative processes that grow the talent pool in imaginative ways, not merely a “fill the pipeline and plug the leaks” approach. Thus, short and longer term investments in talent development can be understood in a more systemic, rather than piecemeal way.

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