Engineering leadership education: an overview of the engineering leadership programs offered in Europe and Australia

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ABSTRACT

In the last ten years, many educational institutions across the globe have implemented engineering leadership programs either as a part of formal engineering curriculum or where leadership development is embedded into separate in-house programs. It has already been identified in research studies that 80-90% of the engineering leadership programs offered explicitly across the globe were based in the United States of America. In Europe and Australia, there is a noticeable lack of engineering leadership programs, particularly in undergraduate curriculum. In Australia, it has been identified that only two universities offered a comprehensive program that catered for engineering leadership. Similarly, Europe is not far ahead. Few engineering universities across the United Kingdom offer leadership programs either as comprehensive degree courses or in modular forms. In the rest of Europe, only Belgium offers a comprehensive explicit program at the postgraduate level. The programs which are offered across Australia and Europe have distinct design and delivery styles but there are certain key features which are common to most of the programs.

Keywords: *Engineering education, leadership, professional development.*

INTRODUCTION

It has been highlighted in the ASCE Task Force Report (Al Khafaji et al 1998, cited in McCuen, 1999) that leadership is vital for professional community to create a competitive environment. According to Bowman and Farr (2000, p. 18), "the key to embedding leadership in the formal education process is to mirror the real world". Engineering as a profession plays a vital role in our society (McCuen, 1999) and therefore engineering education has a responsibility to ensure that engineers are well equipped to take up this role. The primary purpose of offering leadership programs within the engineering education domain is then to produce engineer leaders for the engineering community and society.

Literature reviews and search across university websites have identified that very few engineering leadership programs are being offered across the Europe and Australia. Graham et al (2009) have identified that 80-90% of the engineering leadership programs offered explicitly across the globe were based in the United States of America. The remaining 10-20% of the engineering leadership programs offered explicitly was spread over the rest of the world. In Australia, Monash University is one of the few universities that runs a comprehensive leadership program offered by the faculty of engineering to undergraduate students. In Europe, universities in the United Kingdom are more active in offering engineering leadership programs as compared to rest of the Europe. The Royal Academy of Engineering UK has introduced engineering leadership awards for the engineering undergraduates and postgraduates in collaboration with universities and industry. The Royal Academy of Engineering UK started the engineering leadership advanced scheme in 1996 to help the local engineering students develop leadership skills and realize their potential. In mainland Europe, there is evidence of only one explicit and two non-explicit programs which provide engineering leadership programs in collaboration

with industry. The engineering leadership programs offered in Australia and Europe vary in design and delivery styles.

The purpose of the paper is to identify the key features of the engineering leadership programs offered in the Australian and European universities and institutions. The paper investigates why certain features, particularly professional partnership and communication and teamwork skills, have been targeted by most of the engineering leadership programs. The paper also briefly discusses the rationale of the engineering leadership education.

ENGINEERING LEADERSHIP - RATIONALE

Engineering leadership is the process of envisioning coupled with displaying designing and developing skills to support the strategic objectives of an organization (Shaw, 2002). In real-world situations, technical leaders who are equipped to understand and address significant engineering problems are needed (Engineers Australia, 2010b). Industries now seek engineers who are technically capable as well as possessing leadership skills (The Royal Academy of Engineering, 2007). Conger (1992 cited in Malone, 1995, p. 200) emphasized the need for determining "the right combination of experiential and intellectual instruction" to help develop leadership skills. It can be argued that to produce tomorrow's engineering leaders, universities in collaboration with industry need to offer engineering students more opportunities that can instill leadership qualities and prepare them to take up real-world challenges.

Engineering schools across the world have aligned their mission statements to educate engineering leaders. Stanford University highlights the rationale of providing engineering leadership education by referring to the technological changes and challenging interconnected industries of the world. According to Stanford University, "engineers and technology professionals with strong analytical, managerial, and business skills will be the innovative leaders of tomorrow" to counter technological changes (Stanford Engineering Management and Leadership, 2010). Bernard Gordon, the pioneer of engineering leadership programs at the MIT, advocates for the urgent need for engineer leaders; leaders who can contribute to society as technological innovators. Engineers invent and bring to market new technologies that enable advances in virtually every field including health care, manufacturing, infrastructure, transportation, communications and energy production (MIT Engineering Leadership Program, 2010).

ENGINEERING LEADERSHIP PROGRAMS OFFERED BY THE EUROPEAN AND AUSTRALIAN UNIVERSITIES/INSTITUTIONS

The engineering leadership programs offered in the Europe and Australia have been categorized according to explicit and non-explicit nature of the programs. Graham et al (2009) have identified these two categories of leadership programs which are offered across the world. Explicit programs are those where engineering leadership development is the primary objective whereas, non-explicit programs are those which are included as part of the broader engineering education. The following sections identify and investigate explicit and non-explicit engineering leadership programs offered by the Australian and European universities.

Following programs were identified as explicit in Europe and Australia:

a. Leadership in a Technological Environment Program, Monash University, Australia
b. Doctor of Engineering Practice, University of South Australia
c. Masters in Industrial Leadership, European Institute for Industrial Leadership, Belgium
d. MEng Engineering Design, University of Bristol, United Kingdom
e. Teamwork and Leadership Module, Loughborough University, United Kingdom

Following programs were identified as non-explicit in Europe and Australia:

a. Engineers Without Borders Challenge Program, Engineers Without Borders, Australia
b. The Jacobs Sverdrup Australia Engineering Leadership Prize, Jacobs Sverdrup Australia and University of New South Wales, Australia
c. Dean's Scholars Program, Queensland University of Technology, Australia
d. Global Engineering Teams, Technische Universität Berlin, Germany
e. Project Management in Practice, Universitat Rovira i Virgili, Spain
f. Engineering Leadership Awards, The Royal Academy of Engineering, UK

KEY FEATURES OF THE ENGINEERING LEADERSHIP PROGRAMS OFFERED IN EUROPE AND AUSTRALIA

Table 1 presents common key features of the programs identified by conducting an extensive review of the literature and interviews. Based on this study, the authors have identified some common key features. In Table 1, key features have been grouped in order of most (1) to least common (9):

Table 1: Most Common Key Features.

	Most Common Key Features
1	Professional partnerships, Engineering Schools based
2	Project-based approach, Mentoring (by faculty, fellows, industry etc.), Teamwork/teambuilding
3	Focus – Engineering design, Curricular components/support, Program in operation for over five years, External advisory groups, Opportunities of networking
4	Competitive application and selection process, Industrial experience
5	Focus – Business/entrepreneurship, Leadership seminars/workshops, Leadership theory, Off campus projects, Assessment tools, Opportunities of student scholarships
6	Focus - Environment and Society, Personality profiling exercises, Associated research projects,
7	Intensive transformational experiences, Off-campus camps, International perspective, Personal development plan, Reflective journals/portfolios, Self-evaluation Opportunities, Peer-evaluation Opportunities
8	Campus-based projects, Coaching of junior students, Individually designed programs for each student, Student-led design, delivery and direction

The reason why certain features were selected by the universities was based on the feedback they were provided by employers and industry partners. In case of the University of Bristol UK, the MEng Engineering Design program was inspired by a team of visiting design specialists in a variety of different industrial sectors. The specialists were of the view that there was a need for a set of engineers who would be trained to work on and then lead large scale multi-disciplinary engineering projects. The Leadership in a Technological Environment Program offered by the Monash University, Australia, has also been based on the calls from industry for improved leadership skills and attitudes in engineering graduates and a desire to attract top performing prospective engineering students to the university (Graham et al, 2009). This program has been established after consultations with the members of the Engineering Foundations, industry and alumni. Over the years, The Royal Academy of Engineering UK has established that certain skills were of immense importance for tomorrow's engineers. Their argument is based on the input and feedback they receive from the graduates and industrialists which include the Fellows of The Royal Academy of Engineering.

Table 1 suggests that the professional partnership, communication and teamwork skills are most important components of any engineering leadership program. These key features are being further discussed in the following sections:

Professional Partnership

It can be argued that across the Australian and European universities, professional partnership is considered as the most vital component of any engineering leadership program. 90% of the leadership programs studied had made use of professional partnerships. The partnership was either in the form of mentoring, hosting internships at the workplaces, funding, future employment opportunities or professional networking opportunities. In UK, the University of Bristol has established partnership with industries that support the program in various ways. During the selection process of the students, these partners are actively involved in the interviewing process. They take students on placements during the first summer vacation and in the third year of the course. The university keeps a close liaison with its industrial partners and a faculty member is deputed to liaise for this purpose. In Australian universities there is ample evidence of industrial partnership. It is a requirement laid down by the Australian government under which the students work under the direct supervision of an industrial specialist thus providing students with real-world scenarios and significant leadership development opportunities (Graham et al, 2009). Mentoring has also been considered vital by The Royal Academy of Engineering

UK. The Royal Academy of Engineering provides its candidates Sainsbury Management Fellows as personal mentors. They offer personal advice to the candidates on their personal development and career options.

Communication and Teamwork Skills

The program coordinators at The Royal Academy of Engineering and University of Bristol, United Kingdom, as well as literature review have highlighted the importance of communications skills in the engineering field. It has been reported that the engineers spend 60% of their time communicating with other people (Tilli & Trevelyan, 2008 cited in Trevelyan, 2009). Tenopir and King (2004, p 29-30 cited in Trevelyan, 2009) also reiterated that the time engineers spent on communication ranged from 40% to 75%, with the majority of estimates around 60%. Almost every leadership program that was studied had communication skill as one of the primary elements of the leadership program. The MEng Engineering Design at the University of Bristol UK, runs a comprehensive unit titled 'Research and Communications'. The Royal Academy of Engineering UK offers courses on negotiation skills with emphasis on building communication, presentation and negotiation skills. Monash University Australia covers communication skills in phase one of its leadership program.

Teamwork has also been perceived as highly important for engineers in literature and it is evident by its presence in major engineering leadership programs including MIT engineering leadership program. Teamwork skills were also considered critical for engineers by the participants of a study carried out by Male et al (2010). Loughborough University UK offers a comprehensive module on 'Teamwork and Leadership' to its postgraduate students. Project-based activities at the University of Bristol are also team-based. Monash University Australia offers teambuilding residentials to its engineering students pursuing the engineering leadership program.

CONCLUSION

In Australia and Europe, few engineering leadership programs have been identified. Professional partnership, communication and teamwork skills and engineering schools-based programs were some of the important key features of the programs. It is felt that a concerted effort is required from the engineering schools across Australia and Europe to develop leadership programs to teach models of leadership in engineering contexts. Tomorrow's engineers need to be able to work effectively in an environment that is susceptible to uncertainty. Engineering schools have a task on hand to produce engineer leaders. Engineering schools in Australia and Europe with the help of industry need to develop courses for teaching leadership capacity at undergraduate and postgraduate levels so that a stronger industry-university link develop effective engineering leaders for tomorrow.

REFERENCES

Bowman, B. & Farr, J. (2000). Embedding Leadership in Civil Engineering Education. *Journal of Professional Issues in Engineering Education and Practice*, *126 (1)*, 16-20.

Bristol University (2010). Undergraduate Prospectus 2011. *Engineering Design*. Retrieved April 23, 2010, from http://www.bristol.ac.uk/prospectus/undergraduate/2011/sections /XEND/dept_intro

Constructionarium. (2010). Retrieved April 23, 2010, from http://www.constructionarium.co.uk/

Dean's Scholars Program. (2010). Retrieved April 22, 2010, from http://www.bee.qut.edu.au/study/scholarships /commencing/documents/15060_Real%20Scholar_Deans%20 Prgm.pdf

Engineers Australia. (2010a). The Centre for Engineering Leadership and Management. Retrieved April 22, 2010, from http://www.engineersaustralia.org.au/groups/centre-for-engineering-leadership-and-management/

Engineers Australia. (2010b). The Centre for Engineering Leadership and Management, Retrieved April 22, 2010, from http://www.engineersaustralia.org.au/ieaust/index. cfm?2A90CBDF-B983-705C-DF2C-10A2029831D1

Engineers Without Borders. (2010). Retrieved April 23, 2010, from http://www.ewb.org.au/

European Institute for Industrial Leadership (EIIL). (2010). About the EIIL, 2010. Retrieved Macrh 10, 2010, from http://www.eiil.net/mambo/index.php?option= com_content &task=section&id=11&Itemid=33

Felder, R. M., Woods, D. R., Stice, J. E. & Rugarcia, A. (2000). The Future of Engineering Education: Teaching Methods that Work. *Chemical Engineering Education, 34(1),* 26-39.

Georg, D. (2005). Comfortable outside engineering, *Civil Engineers Australia, 77(3),* 2-3, March.

Global Engineering Teams. (2010). Retrieved April 22, 2010, from http://www.alumni-berlin.de/

Graham, R., Crawley, E. and Mendelsohn, B. (2009). Engineering Leadership Education: A snapshot review of international good practice. White paper sponsored by the Bernard M. Gordon-MIT Engineering Leadership Program.

Loughborough University. (2010). Undergraduate Study, Department of Civil and Building Engineering. Retrieved April 22, 2010, from http://www.lboro.ac.uk/ prospectus/ ug / courses/dept/cv/ce/index.htm

Leadership in a Technological Environment. (2010). Monash University. Retrieved March 2, 2010, from http://www.eng.monash.edu.au/currentstudents/merit/leadership/

Male, S. A., Bush, M. B. and Chapman, E. S. (2010). Perceptions of Competency Deficiencies in Engineering Graduates. *Australasian Journal of Engineering Education, 16(1).*

Malone, P. B. (1995). Developing Leadership Skills. In *Developments in Business Simulations and Experiential Exercises, 22*. The George Washington University.

McCuen, R. H. (1999). A Course on Engineering Leadership. *Journal of Professional Issues in Engineering Education and Practice*, 125 (3), 79-82.

Mihelcic, J. R. (2003). Sustainability Science and Engineering: The Emergence of New Metadiscipline. *Environmental Science and Technology, 37.*

MIT Engineering Leadership Program. (2010). Retrieved May 24, 2010, from http://engineering. mit.edu/education/specialprograms/gordon.php

Monash University. (2010a). Engineering Leadership Program. Retrieved March 11, 2010.

Monash University. (2010b). Leadership in a Technological Environment Program. Retrieved March 11, 2010.

Newport, C. L. and Elm, D. G. (1997). Effective Engineers. *International Journal of Engineering Education, 13(5),* 325-332.

Perth Leadership Institute. (2008). A Recession's Role in Transforming Leadership Development. A whitepaper by *Perth Leadership Institute*. Retrieved May 24, 2010, from http://www.perthleadership.org/Documents/WP_Recession.pdf

Shaw, W. H. (2002). Engineering management in or modern age. Paper appears in *Engineering Management Conference, 2 (2),* 504 – 509.

Stanford Engineering Management and Leadership. (2010). Brochure *Stanford Centre for Professional Development.*

The Royal Academy of Engineering. (2007). Educating Engineers for the 21st Century. London.

Trevelayn, J. (2009). Engineering Education Requires a Better Model of Engineering Practice, Proceedings of the *Research in Engineering Education Symposium* 2009, Palm Cove, QLD.

UniSA. (2010). Doctor of Engineering Practice. Retrieved March 10, 2010, from http://www.unisanet.unisa.edu.au/Programs/program.asp?Program=LPEP&Year=2009.