Courses for teaching leadership capacity in professional engineering degrees in Australia and Europe[1]

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Abstract

Recently 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. This shows a clear intent of these educational institutions to prepare their engineering students for solving the real world problems, recognizing that both technical and leadership skills are valuable for tomorrow's engineers. Leadership programs in engineering education have been implemented in various formats with varying degrees of success. 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. However, 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 and both of them were at the post-graduate level. There are other leadership initiatives undertaken by industry in Australia in collaboration with universities but non-explicit in nature. 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 including professional partnerships, mentoring, engineering design and project-based approaches.

1. Introduction

The primary purpose of providing or offering leadership programs within the engineering education domain is to produce leaders for the engineering community and society. 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. Hilton (1996, cited in McCuen, 1999, p. 79) reiterates that "engineering schools must better train engineers for leadership roles" in order to maintain the stature of the engineering profession. In the last ten years, few universities across the globe have embarked on the mission to impart engineering leadership education. Professional associations have now also realized that it was about time that the engineers were equipped with necessary leadership skills. Therefore, a need has arisen for the engineering students to develop leadership skills to remain competitive (Felder et al, 2000).

Interviews, literature reviews and search across university websites have identified that very few explicit 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. The engineering leadership programs offered in Australia and Europe are few and vary in design and delivery styles. There are certain key features which are fundamental to most of these programs. These features are generally identified by the combined efforts of the university, industrial partners and specialists.

This paper identifies and investigates engineering leadership programs offered in the Australian and European universities and institutions. This paper also investigates key features of these programs and proposes an 'ideal' engineering leadership program based on literature review, interviews and existing best practices. Barriers and challenges faced by the engineering leadership education are also briefly discussed.

2. Engineering Leadership Courses

Leadership as a concept is a trivial task to define. Within the context of engineering education, authors are of the view that leadership not just consists of the technical knowledge and skills but also the ability to lead and motivate subordinates to successfully achieve

desired outcomes. A leader is responsible for identifying problems and providing a vision. Today's global market environment provides tremendous technical leadership challenges. Engineering as a profession plays a vital role in our society (McCuen, 1999). Engineering education therefore has a responsibility to produce future leaders who can manage change and have poise and the urgency to deal with it. According to Reeve et al (2010) 'there is a need to prepare engineering students to address increasingly complex global challenges'.

Engineering education provides technical excellence which is an essential foundation for engineering leadership (Reeve et al, 2010). Reeve et al (2010) have identified that there was a development within the engineering leadership education to deliver leadership education in order to empower engineers to fulfill their goals and have greater impact in the world. These arguments were based on the successful implementation of leadership programs which were being delivered at the MIT, Penn State, Tufts and other prestigious US engineering schools.

Engineering leadership is the process of envisioning coupled with displaying designing and developing skills to support the strategic objectives of an organization including new products and services to a set of requirements, within budget and to a schedule with acceptable levels of risk (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 students have tremendous potential, and given opportunities to develop themselves as leaders, that potential would be increased.

Graham et al (2009) report that the majority of programs offering engineering leadership educations are based within the US and most is relatively new. In Europe and Australia, there is a noticeable lack of engineering leadership programs, particularly in undergraduate curriculum. It is also evident from Graham et al who state that, "the notion of educating students in leadership clearly does not sit comfortably with many engineering faculty in Europe, and very few European programs have been identified in the study that explicitly use the term leadership in the course description" (Graham et al, 2009).

Graham et al (2009) have identified two categories of leadership programs which are offered across the world; explicit and non-explicit. 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. There is a strong possibility that some existing non-explicit programs may not be visible outside universities. The following sections identify and investigate explicit and some of the non-explicit engineering leadership programs offered by the Australian and European universities.

2.1. Explicit and Non-explicit Programs offered by the Australian Universities/Institutions

The following programs were identified as explicit in Australia:

a. **Leadership in a Technological Environment Program**, Monash University
b. **Doctor of Engineering Practice**, University of South Australia

The following programs were identified as non-explicit in Australia:

a. **Engineers Without Borders Challenge Program**, Engineers Without Borders
b. **The Jacobs Sverdrup Australia Engineering Leadership Prize**, Jacobs Sverdrup Australia and University of New South Wales
c. **Dean's Scholars Program**, Queensland University of Technology

2.3 Explicit and Non-explicit Programs offered by the European Universities/Institutions

The following programs were identified as explicit in Europe:

a. **Masters in Industrial Leadership**, European Institute for Industrial Leadership, Belgium
b. **MEng Engineering Design**, University of Bristol, United Kingdom
c. **Teamwork and Leadership Module**, Loughborough University, United Kingdom

The following programs were identified as non-explicit in Europe:

a. **Global Engineering Teams**, Technische Universität Berlin, Germany
b. **Project Management in Practice**, Universitat Rovira i Virgili, Spain
c. **Engineering Leadership Awards**, The Royal Academy of Engineering, UK
d. **Constructionarium**, Constructionarium Ltd, United Kingdom

3. Key Features of the explicit and non-explicit programs offered in Australia and Europe

It was identified by the authors that most of the engineering leadership programs offered explicitly across Australia and Europe were:

a. University based (with the exception of the Masters in Industrial Leadership, offered at the European Institute for Industrial Leadership, Belgium), and

b. Offered at postgraduate level (with the exception of a non-award program offered at the Monash University, Australia)

Tables 1, 2 and 3 detail key features of the explicit and non-explicit programs offered in Australia, United Kingdom and mainland Europe. These features have been identified by conducting an extensive review of the literature and interviews (Appendices A and B). This exercise also draws attention to the differences and similarities between explicit and non-explicit leadership programs in various contexts.

Programs	Explicit Programs		Non-Explicit Programs			Number of occurrences
	Leadership in a Technological Environment Program	Doctor of Engineering Practice	Engineers Without Borders Challenge Program	The Jacobs Sverdrup Australia Engineering Leadership Prize	Dean's Scholars Program	
Awarding Organizations	Monash University	University of South Australia	Engineers Without Borders Australia	Jacobs Sverdrup Australia and University of New South Wales	Queensland University of Technology	
Offered to	Local and international high school students who have completed year 12	Individuals currently employed with bachelor or master's degrees	First year university students	UNSW Engineering undergraduates	High school students entering QUT	
Duration	Three years	Three/Five years	15% of one semester's work load	Award is a one-off payment of $2750	Four years	
Focus - Environment and Society	✓	Postgraduate Research Degree	✓			2
Focus – Business/entrepreneurship	✓					1
Focus – Engineering design			✓		✓	2
Professional partnerships	✓		✓		✓	3
Learning outcomes						0
Leadership seminars/workshops	✓		✓		✓	3
Leadership theory	✓					1
Project-based approach	✓		✓			2
Personality profiling exercises	✓					1
Intensive transformational experiences			✓			1
Campus-based projects						0
Off campus projects			✓			1
Off-campus camps	✓					1
International perspective			✓			1
Coaching of junior students						0
Mentoring (by faculty, fellows,	✓		✓		✓	3

industry etc.)						
Personal development plan	✓					1
Reflective journals/portfolios						0
Self-evaluation Opportunities	✓					1
Peer-evaluation Opportunities						0
Assessment tools	✓					1
Individually designed programs for each student						0
Curricular components/support	✓		✓		✓	3
Associated research projects	✓		✓			2
Competitive application and selection process	✓				✓	2
Opportunities of student scholarships	✓				✓	2
Dissemination and outreach						0
Program in operation for over five years					✓	1
Student-led design, delivery and direction						0
Engineering Schools based	✓				✓	2
Business Schools based						0
External advisory groups			✓		✓	2
Teamwork/teambuilding	✓		✓			2
Opportunities of networking	✓		✓		✓	3
Industrial experience	✓				✓	2

Table 1: Key Features of the Explicit and Non-explicit Leadership Programs offered in Australia

Programs	Explicit Programs		Non-Explicit Programs		Number of occurrences
	MEng Engineering Design	Teamwork and Leadership Module	Engineering Leadership Awards	Constructionarium	
Awarding Organizations	University of Bristol	Loughborough University	The Royal Academy of Engineering	Constructionarium Ltd	
Offered to	High school students who have completed A Levels	MEng students	Local and international engineering undergraduates	Students and young professionals	
Duration	Five years	6 months (semester long)	Award for duration of the degree	6 day working field course	
Focus - Environment and Society	✓				1
Focus - Business/entrepreneurship	✓		✓	✓	3
Focus - Engineering design	✓			✓	2
Professional partnerships	✓	✓	✓	✓	4
Learning outcomes		✓		✓	2
Leadership seminars/workshops			✓		1
Leadership theory		✓			1
Project-based approach	✓	✓	✓	✓	4
Personality profiling exercises	✓		✓		2
Intensive transformational experiences		✓		✓	2
Campus-based projects	✓				1
Off campus projects	✓		✓	✓	3
Off-campus camps		✓		✓	2
International perspective			✓		1
Coaching of junior students			✓		1
Mentoring (by faculty, fellows, industry etc.)	✓		✓	✓	3
Personal development plan	✓		✓		2
Reflective journals/portfolios		✓		✓	2
Self-evaluation Opportunities		✓			1
Peer-evaluation Opportunities	✓	✓		✓	3
Assessment tools	✓	✓			2
Individually designed programs for each student	✓		✓		2
Curricular components/support	✓	✓		✓	3

Associated research projects	✓			✓	2
Competitive application and selection process	✓		✓		2
Opportunities of student scholarships	✓		✓		2
Dissemination and outreach				✓	1
Program in operation for over five years	✓	✓	✓	✓	4
Student-led design, delivery and direction			✓		1
Engineering Schools based	✓	✓	✓	✓	4
Business Schools based					0
External advisory groups	✓		✓	✓	3
Teamwork	✓	✓		✓	3
Opportunities of networking	✓		✓		2
Industrial experience	✓		✓		2

Table 2: Key Features of the Explicit and Non-explicit Leadership Programs offered in the United Kingdom

Programs	Explicit Programs	Non-Explicit Programs		Number of occurrences
	Masters in Industrial Leadership	Global Engineering Teams	Project Management in Practice	
Awarding Organizations	European Institute for Industrial Leadership, Belgium	Technische Universität Berlin, Germany	Universitat Rovira i Virgili, Spain	
Offered to	Engineering undergraduates	Engineering and science students	Fourth Year engineering students	
Duration	Two years	18 weeks	30 weeks	
Focus - Environment and Society		✓		1
Focus - Business/entrepreneurship	✓			1
Focus - Engineering design	✓	✓	✓	3
Professional partnerships	✓	✓		2
Learning outcomes				0
Leadership seminars/workshops	✓			1
Leadership theory	✓	✓	✓	3
Project-based approach		✓	✓	2
Personality profiling exercises			✓	1
Intensive transformational experiences				0
Campus-based projects		✓	✓	2
Off campus projects		✓		1
Off-campus camps				0
International perspective		✓		1
Coaching of junior students			✓	1
Mentoring (by faculty, fellows, industry etc.)		✓	✓	2
Personal development plan				0
Reflective journals/portfolios		✓		1
Self-evaluation Opportunities			✓	1
Peer-evaluation Opportunities				0
Assessment tools		✓	✓	2
Individually designed programs for each student				0
Curricular components/support	✓			1
Associated research projects				0
Competitive application and selection process		✓	✓	2

Opportunities of student scholarships	✓			1
Dissemination and outreach				0
Program in operation for over five years	✓		✓	2
Student-led design, delivery and direction			✓	1
Engineering Schools based	✓	✓	✓	3
Business Schools based				0
External advisory groups	✓	✓		2
Teamwork	✓	✓	✓	3
Opportunities of networking	✓	✓		2
Industrial experience	✓	✓		2

Table 3: Key Features of the Explicit and Non-explicit Leadership Programs offered in the Europe (excluding UK)

Based on this study, the authors have identified some common key features. In Table 4, key features have been grouped in order of most (1) to least common (9):

Order	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	Learning outcomes, Campus-based projects, Coaching of junior students, Individually designed programs for each student, Student-led design, delivery and direction
9	Dissemination and outreach

Table 4: Most Common Key Features

4. Discussion – Most Common Key Features

4.1 Rationale

The rationale behind selecting these features was based on the feedback universities 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 Royal Academy of Engineering UK and a wide range of industrial companies have also helped develop this program. 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, engineering leadership advanced awards alumni and industrialists which include the Fellows of The Royal Academy of Engineering.

4.2 Common Key Features

4.2.1 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. They give talks on areas of engineering in which they have special expertise e.g. Rolls Royce on advanced aero engine design, Renishaw on light and its use for high precision measurement. 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).

4.2.2 Communication Skills

Interviews with 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 engineers spend 60% of their time communicating with other people (Tilli & Trevelyan, 2008, Tenopir & King, 2004, cited in Trevelyan, 2009). 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.

4.2.3 Teamwork

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.

4.2.4 International Perspective

There was ample evidence of provision of international perspective in the engineering leadership programs studied. International perspective is must for engineers of tomorrow if they want to take up the leadership role of improving the global community (Mihelcic et al, 2003). One of the competencies prescribed by the Engineers Australia is the 'understanding of social, cultural, global, and environmental responsibilities and the need to employ principles of sustainable development' (Engineers Australia, 2006). To produce effective engineers, universities and educators have to provide engineering students with a broad knowledge base which encompasses political, environmental, business and community areas in addition to technical knowledge (Newport & Elms, 1997).

4.2.5 Mentoring

Mentoring has been considered vital especially by The Royal Academy of Engineering and University of Bristol 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. Project-based learning is being paid more attention recently. According to a whitepaper sponsored by Gordon MIT Engineering Leadership Program, many universities in the UK have shown interest in project-based learning approach. About 83% of the programs studied have employed this approach.

5. Business Management Programs – Engineering Leadership Development

Goh et al (2009) are of the view that MBA programs are not adequate to provide the personal, professional and educational development of engineering managers. Nevertheless, it has been observed that aspiring engineering managers acquire MBA qualifications to climb up the corporate ladder. In addition, it has been identified that engineering schools offer management training based around leadership and management skills through partnership with business schools examples include Master in Engineering and/or Project Management.

6. Engineering Leadership Education – Challenges and Barriers

Industries are not mandated to provide training programs for skills that help develop employees in areas of team building, interpersonal and communication skills. Some do provide such training but by and large engineers learn and develop leadership skills on the job (Bowman and Farr, 2000). If proper coaching is not provided then this approach can require years of experience. In 1998, The Royal Academy of Engineering realized that a cohort of "elite" engineers was needed who would also become an inspiration to the next generation of engineers to keep the interest of engineering within the UK growing. It was felt that to make engineering field in the UK more competitive and robust in times of economic turmoil, engineers with effective leadership skills were needed. Therefore, engineering courses at universities are required to incorporate management and leadership subjects to address this problem (Georg, 2005).

This paper has identified that the number of explicit engineering leadership programs offered in Australia and Europe is minimal. One of the reasons many Australian and European engineering schools have not implemented explicit leadership courses/programs can be reliance on programs offered by respective management schools. As an example, Brisbane Graduate School of Business at the Queensland University of Technology offers Executive MBA which is designed to develop highly-skilled business leaders. Such programs do not necessarily aim engineering leadership but provide opportunities for people who have qualifications in non-business field and want to strengthen their management capabilities.

Most of the explicit programs identified are offered at the postgraduate levels. In Australia, the University of South Australia offers a doctorate program. In United Kingdom, the two universities offering the programs are at post-graduate levels. In Belgium, it is also offered at the graduate level. However, a Spanish university offers a course for its fourth year undergraduate students and this university can be said to lead Europe in undergraduate engineering leadership course. Similarly, there are also other engineering leadership initiatives across Europe but again they are not integrated into the undergraduate degree programs. It can be argued that Monash University is the leader in Australia based on the comprehensive structure of the engineering leadership program and well defined objectives (Monash University, 2010b). There are some other engineering leadership initiatives in Australia like that offered by Queensland University of Technology (QUT) to the top students but they are not integrated into the degree programs.

Professional associations have also shown interest in leadership initiatives. Engineers Australia, in order to meet the 'demands of the complex and changing business environment in which engineers work', has established the Centre for Engineering Leadership and Management (CELM) (Engineers Australia, 2010a). CELM has initiated the Year of Engineering Leadership by organizing the 'Engineering Leadership Conference' in May 2010 in Brisbane.

Recent economic turmoil also poses challenges to the engineering leadership education. According to the Perth Leadership Institute (2008), 'economic slowdowns and recessions undergo highly predictable patterns'. Market approaches peak before the slowdown occurs

accompanied by great deal of complacency amongst companies, staffs, shareholders and investors. But this does not last long and then the unpredictable happens; economic collapse. 'One typical impact is for leadership development budgets and efforts to be cut' (Perth Leadership Institute, 2008). Funding thus clearly becomes a challenge not only for developing engineering leadership programs but for education in general.

Graham et al (2009) are of the view that there is a dearth of expertise and resources currently available to engineering schools wishing to establish new programs of engineering leadership education. This study also revealed difficulties in identifying and recruiting qualified teaching staff for developing and delivering engineering leadership programs. The University of Bristol UK, is of the view that there is no shortage of specialized engineering teaching staff at the university however employing appropriate teaching staff for the non-specialized units (e.g. Research and Communications unit) and for supervising industrial projects is a challenge. The faculty at the university had to employ consultants from the industry to fill up the gap.

7. Proposed Engineering Leadership Program - A Brief Model

An engineering leadership model is being proposed considering the common key features of the leadership programs identified in Australia and Europe and literature review of the existing best practices in the United States of America. The corner stone of this program is 'industrial partnership' based on the study carried. This model is based on two modules to be offered to the engineering students in separate years of study.

Broadly, following is being proposed:

a. Focus to be engineering design/research
b. Engineering leadership programs to be run by the engineering schools/faculty
c. Universities to establish strong partnership with industry so that professional mentoring is provided to the engineering students
d. Project-based learning (module 2)
e. Modular structure

The program is designed in a modular form which can be offered in the first and third year, with emphasis on professional mentoring and industrial experience. The central idea of module 1 will be 'communication skills' with emphasis on research and presentation skills. Students will be required to thoroughly research a selected engineering topic and give a presentation; both written and oral. Emphasis will also be on teamwork development and mentoring. Figure 1 shows the major elements of the proposed module 1.

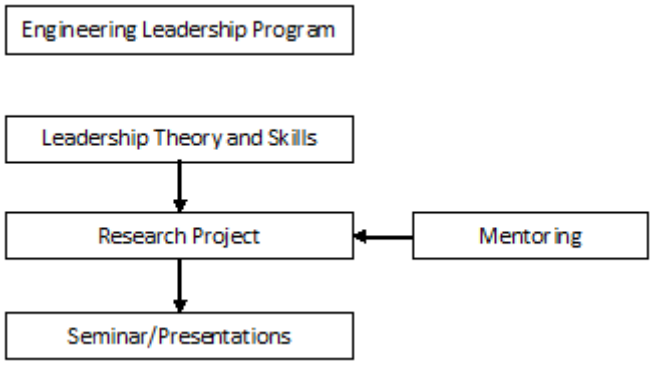

Figure 1: Proposed Engineering Leadership Program – Module 1

In module 2, a project-based learning approach is suggested. Students will be presented with projects/problems in consultation with industry partners. The rationale for incorporating project-based learning is that the students who participate in project-based learning are generally motivated by it and demonstrate better teamwork and communication skills (Mills & Treagust, 2003). In addition they have a better understanding of the application of their knowledge in practice and the complexities of other issues involved in professional practice (Mills & Treagust, 2003). Students will work in teams under the supervision of the engineering faculty and industrial mentors. The central idea of this module is project-based learning coupled with industrial experience. Figure 2 shows the major elements of the proposed module 2.

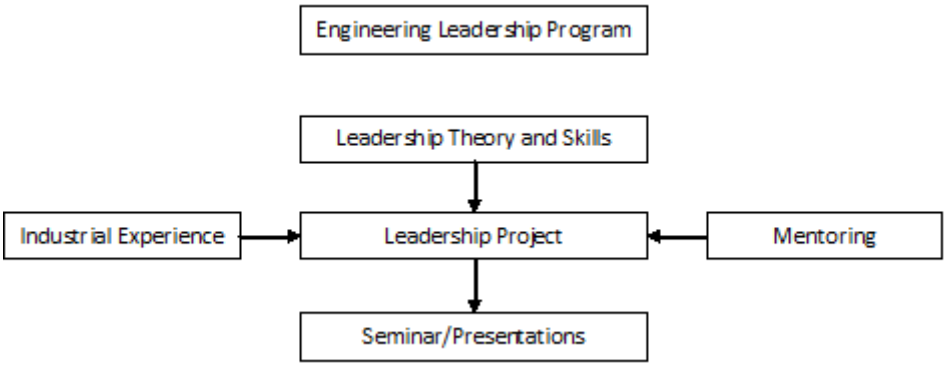

Figure 2: Proposed Engineering Leadership Program – Module 2

8. Conclusion

In Australia and Europe, few engineering leadership programs have been identified. 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.

Engineering schools in Australia and Europe need to take a holistic approach to transform engineering leadership in their respective continents.

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Appendix A

MEng Engineering Design – University of Bristol, UK

Following is the summary of the interview conducted with Mr J H Sims Williams, Coordinator MEng Engineering Design Program, University of Bristol, United Kingdom, on Tuesday, 27th July 2010, from 1.30 pm to 3.30 pm.

Before the start of the interview, Mr William's consent was sought for using any commentary for educational purposes. The following responses have been paraphrased.

1. Can you briefly describe the MEng Engineering Design program offered at the University of Bristol?

The MEng Engineering Design degree is a five year program and it aims to educate and train students for future leadership roles in industry. In the third year of program, which is titled as the industrial placement year, students are given a year of industrial experience. The purpose of the placements is to provide an understanding of real engineering and enable students to see a relevance of their academic studies. The third year is so designed that it also improves students' competence at making both oral and written reports and in planning and managing their workload. In the first summer vacation, the students are offered placements with the companies. The idea is to help students financially as well as helping them to understand the sort of work that they would like to do after graduation.

Other benefits are: students on this course having worked in industry are more confident about working in industry and having had good experiences of doing so, tend to choose industrial work as a career more than students on other courses. They also enhance their understanding of those aspects of engineering in which they work and so contribute to the student cohorts' appreciation of engineering problems and processes when they work together on projects later in the course.

MEng Engineering Design Program was first offered in the year 2001 and since then about 250 students have graduated.

2. What was the rationale for offering the MEng Engineering Design program at the University of Bristol?

The University of Bristol has had long-term partnership with industries. At the moment, there are 15 international industrial partners which support this program. This link has helped the university to get firsthand knowledge about the employment market and current trends in the industrial sectors. 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 Royal Academy of Engineering UK and a wide range of industrial companies have also helped develop this program.

The broader aim of the degree is to help form leaders of engineering; leaders who have well developed leadership skills and specialized knowledge. For this purpose, it is intended that the students will have a very good understanding of the key concepts lying behind all the subjects they study. 'Research and Communications' unit, which is covered over four years of the degree, aims at helping the students to learn how to research engineering topics and then communicate them. The focus of the research is Manufacturing and Engineering Fundamentals.

3. What is the rationale behind targeting certain leadership skills?

According to the University of Bristol, the industrial advisors insist that the leading graduates they recruit must have an extremely good understanding of engineering concepts and principles across a wide spectrum of engineering. The graduates are expected to be expert in some engineering discipline and they must be excellent at communicating their ideas. In addition to these skills, industrial specialists believe that students need to learn economic and legal mechanisms of bringing about change, as well as the direct effects of engineering systems on the environment. It is believed that successful students will be highly valued in the employment market. Therefore, the program is aimed at students who have broad engineering interests and who will want to work on and eventually lead large-scale and challenging projects that have a significant impact on society and the environment.

4. **How are industrial partners involved in the development/running of the MEng Engineering Design program at the University of Bristol?**

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. They give talks on areas of engineering in which they have special expertise e.g. Rolls Royce on advanced aero engine design, Renishaw on light and its use for high precision measurement.

5. **What is the evidence of success of the program? What differentiates these graduates from other engineering graduates?**

The university gets feedback from the industrial partners, which so far has been extremely positive. There are numerous employment opportunities for the engineering graduates who undertake this program.

6. **Has any problem been experienced during the development and actual running of the program?**

This program is being run by the engineering faculty of the university. Although there is no dearth of specialized engineering teaching staff at the university however employing appropriate teaching staff for the non-specialized units (e.g. Research and Communications unit) and for supervising industrial projects was a challenge. The faculty had to employ consultants from the industry to fill up the gap. Such consultants bring in vital industrial experience with them.

7. **Do you think the university could/should train/prepare teaching staff for taking up teaching assignments for the non-specialized units in the program? Wouldn't it, in the longer run, minimize the stress on employing consultants from outside the university?**

Universities are assessed according to their research output and so they tend to appoint staff who are good at research. It is much easier to obtain a good rating in research if one works in a narrow field of study and become a world class expert in this very narrow field. This means that generalists almost don't exist in universities and it is easier to recruit non-permanent staff from outside to fulfill this role.

Appendix B

Engineering Leadership Scheme – The Royal Academy of Engineering, UK

Following is the summary of the interview conducted with Mr Usman Akram, Engineering Leadership Awards (ELA) Scheme Coordinator, The Royal Academy of Engineering, United Kingdom, on Wednesday, 21st July 2010, from 11 am to 1 pm.

Before the start of the interview, Mr Akram's consent was sought for using any commentary for educational purposes. The following responses have been paraphrased.

1. **Can you briefly describe the engineering leadership scheme offered at The Royal Academy of Engineering?**

   The Engineering Leadership Scheme run by The Royal Academy of Engineering offers two kinds of awards: standard and advanced awards. Standard award is a leadership scheme where we offer a number of free courses to undergraduate students throughout the year, whereas the advanced awards is offered to the local as well as international engineering students, the scheme is designed to accelerate the awardees personal development towards leadership in engineering. So far about 419 awards have been given since the start of the advanced scheme (1996) and 849 standard awards have been given since the start of the scheme (2008).

2. **What was the rationale for offering engineering leadership awards by The Royal Academy of Engineering?**

   The Royal Academy of Engineering started the engineering leadership advanced scheme in 1996 to help the local engineering students develop leadership skills and realize their potential. It was felt that to make engineering field in the UK more competitive and robust in times of economic turmoil, engineers with effective leadership skills were needed, The Royal Academy of Engineering also realized that a cohort of "elite" engineers would also have to become an inspiration to the next generation of engineers to keep the interest of engineering within the UK growing. It is now evident that globalization and formation of EU has had

implications for the UK economy in general and industries in particular. To achieve a winning edge in technology and ensure that UK engineering students were equipped with necessary skills to lead in times of uncertainty and change, The Royal Academy of Engineering embarked on providing world class leadership development opportunities for the engineering students. The engineering leadership standard award scheme started in 2008 to help develop a further interest in engineering and open up opportunities for UK engineering undergraduate through free courses offered by The Royal Academy of Engineering. The Royal Academy of Engineering had the data from university institutes and contacts within the industry to find that UK engineering graduate were losing the interest in engineering and moving to profession away from engineering i.e. banking, finance. With engineering graduate also finding it a difficult task to find engineering employment, the standard award was designed to provide small technical and interpersonal skills training in leadership and management skills.

3. What is the rationale behind targeting certain leadership skills?

Over the years, The Royal Academy of Engineering has established that certain (broader) skills including negotiation, project management, and public engagement skills, just to name a few, were of immense importance for tomorrow's engineers. Their argument is based on the input and feedback they receive from the graduates and industrialist which include our Fellows of the Royal Academy of Engineering. The engineering leadership advanced awards alumni also have an input in the different leadership skills that are needed. The academy runs exclusive workshops/courses for the above mentioned skills on the standard award scheme whereas the advanced awardees are exposed to an intense training weekend every year of their award period (3 years). The academy is also of the view that activities that target team building skills, based on practical work and challenging activities, enable engineering students develop leadership skills required for those who would work in multi-disciplinary team environments.

4. The academy's website mentions that the 'outstanding students' are offered these awards. How does the academy define the 'outstanding student'?

The Royal Academy of Engineering ***does not only*** *consider the academic standing of an applicant but it follows a thorough selection process in which many aspects are taken into*

consideration. In case of Advanced Awards, the applicants must apply through our website before a deadline, once submitted the applications are blind marked by a selection panel, from which 70 are drafted into a selection event over a weekend at the University of Warwick which consists of a business game simulation exercise and a 45 minute interview with a Fellow of The Royal Academy of Engineering and Sainsbury Management Fellow. Up to 40 awards can be made each year as part of the advanced award scheme. After the selections have been made the awardees are allocated a mentor based on their geographical location and engineering discipline, the student must also write a proposal outlining their plans and career intentions called the 'Personal Development Plan'. The whole process is intended to make sure that only the best candidates who aspire to become future leaders within the engineering field are selected.

5. Who are mentors and why are they selected for mentoring ELA candidates?

Mentors are engineering professionals with immense experience in their respective fields. Most of them are senior executives holding top positions within their organizations. These individuals have professional standing amongst their peers locally and globally. Sainsbury Management Fellows are provided as mentors and advisors to the candidates who are offered the advanced awards. The Royal Academy of Engineering is of the view that leadership development training coupled with professional mentorship provides candidates the rare opportunity of not only developing skills but also professional networks. The academy believes that in today's technological world, where boundaries overlap due to the dynamics of the industry, networking is as important as developing any core leadership skill.

6. What is the evidence of success of the program?

The Royal Academy of Engineering keeps a track record of its awardees even after graduation. They are encouraged and invited to talk to and mentor new candidates. The academy has show-cased success stories of awardees' success after graduation in their respective employments on the academy's website, which also serves as an evidence of the success of the scheme. The success of the scheme can also be measured in terms of sponsorships, partnership with the Engineering Construction Industry Training Board (ECITB), Laing O'Rourke, Cranfield University, Engineers Without Borders (EWB) UK, and partnerships with educational institutions. The Royal Academy of Engineering has been successful in

securing sponsorship from Shell, which has enabled it to extend the Engineering Leadership Advanced Award Scheme to include non-UK MEng students. The academy has developed strong partnership with universities and currently many programs are being run in collaboration with UK universities.